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SETTLEMENT OF NOMADIC AND SEMI-NOMADIC TRIBAL GROUPS IN THE MIDDLE EAST[1]

BY

MOHAMED AWAD

The lands of the Middle East[2] are inhabited mainly, though not exclusively, by Arabic-speaking peoples, who are collectively described as Arabs, whether they lead a sedentary, a semi-nomadic or a nomadic life[3]. In some countries, however, particularly in Egypt, the term «Arabs» is sometimes used in a more restricted sense to denote tribal groups, whether nomadic, semi-nomadic or sedentary; and as long as they possess a tribal organisation they are referred to as «Arabs» to distinguish them from the settled peasants or «fellaheen»[4].

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[1] The Editor of «*Bulletin de la Société de Géographie d'Egypte*» deeply thanks the International Labour Office (Geneva) for the authorisation to reproduce this article which has been published in the International Labour Review (Vol. LXXIX, N° 1, pp. 25-55, Jan. 1959).

[2] The term Middle East has often been described as rather vague, but for the purpose of the present study it has been limited to three fairly distinct areas: (*a*) the lands bordering the Nile Valley, including both Egypt and the Northern Sudan; (*b*) the lands of the so-called Fertile Crescent, comprising Iraq, Syria, Lebanon, Palestine and Jordan; (*c*) the Arabian Peninsula. The domain of the nomad is much larger, but even when thus limited it is still far too large for adequate treatment, in a single article, of all aspects of nomadic life. A certain amount of selection will be inevitable both as regards the groups and the details of their living conditions.

[3] In the Arabic language a distinction is made between the word ʿArab, i.e. people of Arab culture as a whole, and the word Aʿrab, which means Bedouins or Arab nomads. This distinction is not often observed, and we come across writing where the word Arab is loosely used to signify tribal groups in Arabic speaking countries.

[4] See Mohamed Awad, «The Assimilation of Nomads in Egypt», *American Geographical Review*, Vol. XLIV, p. 245.

The people concerned are largely Moslem as well as Arabic-speaking, although there are, especially in Africa, sections which are not of Arabian origin. This is notably the case with the Hamitic Beja, living between the Nile and the Red Sea, north of the Abyssinian Plateau, who have a special language of their own, *To Bedawi,* and who, though partially Arabised, must be considered as a distinct group. Many writers consider that the same should apply also to the tribal groups living in the Libyan desert west of the Nile, who, though more thoroughly Arabised than the Beja, contain a considerable proportion of Berber blood [1]. They do not possess, at present, any special language of their own [2]. But in spite of many similarities common to all tribal groups, both the Beja and the Libyans display certain social features peculiar to themselves, notably as regards mother-right and the position of women in general.

Living Conditions of Nomadic, Semi-Nomadic and Settled Tribal Groups

Nomadic Groups

Throughout the lands of the Middle East, tribes and tribal groups are widely spread, but they do not constitute the whole population and seldom even a majority of the population in any political unit, except in Saudi Arabia. Tribal groups are usually classified into nomadic, semi-nomadic and sedentary tribes, their essential characteristic being that their members are distinguished by belonging to a specific group, and not to a specific place, village or town. They retain this characteristic even when they constitute a fixed agricultural community.

At present « pure » nomads, leading a wandering life, are relatively few, probably not exceeding 750.000 throughout the area under consideration. Semi-nomadic tribes in the same countries would probably reach about 2 million, while sedentary groups with a tribal organisation should easily reach, or even exceed, 5 million. It is impossible to give a more accurate figure since the usual official statistical sources contain only rough estimates with regard to all these categories, especially the wandering nomads.

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[1] See G. W. Murray, *Sons of Ishmael* (London, George Routledge and Sons, 1935), pp. 271 ff.

[2] In the Oasis of Siwa (Jupiter-Ammon) a special Berber dialect survives.

The size of a tribe varies considerably, according to environment and occupation, and tends to increase under sedentary or semi-sedentary conditions. Absolute nomadism has a restrictive influence on size, because of the need for maintaining a certain amount of contact among members while pursuing a nomadic existence. A nomadic tribe is usually counted by tents; and while some very powerful tribes, like the Ruwala may consist of some 3.500 tents, a much more modest figure of about one thousand or even a few hundred is more generally the rule.

If a tribe grows beyond a certain point under nomadism, it begins almost automatically to disintegrate into tribal sections, which subsequently develop into separate tribes, occupy different domains and are often in conflict with one another. A very good example of this is the ʿAnaza tribe, widely spread throughout Arabia and the Fertile Crescent, and consisting of over 20.000 tents, which has split up into several conflicting sub-tribes [1].

A tribe which becomes partly or wholly sedentary often grows to considerable proportions, in accordance with the growth of the means of subsistence. The Hadendowa of the Sudan, a Beja tribe of over 100.000, and the Awlad ʿAli of Egypt, who probably exceed that number, are good examples of semi-nomadic tribes which have increased steadily in the past fifty years. It is true that some of this growth is due to the absorption of smaller tribal sections, but it could not have taken place under purely nomadic conditions.

The characteristics of the purely nomadic tribe cannot be discussed here in full. It is important to note, however, that no tribe, no matter how nomadic it may be, leads an indefinite wandering life, without any regard to prescribed routes and landmarks. The nomads we are dealing with are pastoral nomads, with large herds of camels and a few other animals. They are habitually on the move, travelling sometimes by day and sometimes by night according to the season, for about nine months in the year. But in these wanderings, whose object is to procure water and pasture for their herds, they follow fairly fixed routes, and

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[1] See C. Daryll Forde, *Habitat, Economy and Society,* 7th edition (London, Methuen, 1949), p. 310.

usually return to the point from which they started. Here they generally loiter a little longer, to dispose of their surplus animals and buy much of their provisions; and it is this « starting point » which habitually determines the land or country to which they « belong ».

Throughout their wanderings, however, they keep to lands and wadis, wells and springs and oases, which they claim as their own; and as long as they can defend their claim by force of arms, there are few who care to contest it, except when hostilities are intended. Tribal boundaries are often the subject of dispute and this merely expresses the conception that each tribe has its own land, with its water and pasture, and should not trespass beyond its limits. It is of course possible that some Bedouin might ask permission to graze their cattle on the lands of another tribe; such permission is seldom denied, but the fact that it must be sought demonstrates the right of each tribe to its land.

Such lands are of course mostly arid with some grazing patches, wells and even springs scattered here and there. But no matter how arid a land may be, it is never sufficiently barren to be considered worthless [1]. It is always claimed by some tribe and defended to the utmost against any encroachment. But as soon as a tribe detects any weakness in any of its neighbours—and Bedouin are extremely sensitive to such signs of weakness—they at once engage in hostilities, with the object of acquiring all or part of their neighbours' land.

The nomads thus lead a wandering life, with a fairly fixed annual cycle, generally following the same routes. They usually travel in rather small bands of about twenty to thirty tents, in order to avoid crowding at wells and pastures. A good example of a nomadic tribe is the Ruwala of Eastern Syria, who congregate in their « homeland », east of Damascus during the summer and early autumn. Here they sell their surplus

[1] See C. S. Jarvis, *Yesterday and To-day in Sinai* (Edinburgh and London, William Blackwood and Sons, 1931), pp. 60 and 67, and Abbas Ammar, *The Eastern Gates to Egypt* (published by the author in Arabic. Cairo, 1946), p. 142. Governments do not admit this right of ownership. They allow the nomads to use the lands but reserve the right to take it away at any time. Governments, however, are interested in the limits of the land occupied by each tribe, as a means of fixing the responsibility for crimes committed.

animals and purchase their provisions, mostly flour, dates, rice, coffee and sugar, and some articles of clothing. Late in September they begin their trek, passing the winter in the Syrian desert, and the spring in the oases of Jauf and Tayma in north-western Arabia before they begin their return journey back to Syria. The area in which these wanderings take place is about 500 miles long as the crow flies from north to south, and about 300 miles from east to west, but as the Ruwala pursue a somewhat irregular course it is probable that in their annual wanderings they cover some 1.500 miles.

SKETCH MAP OF RUWALA TERRITORY

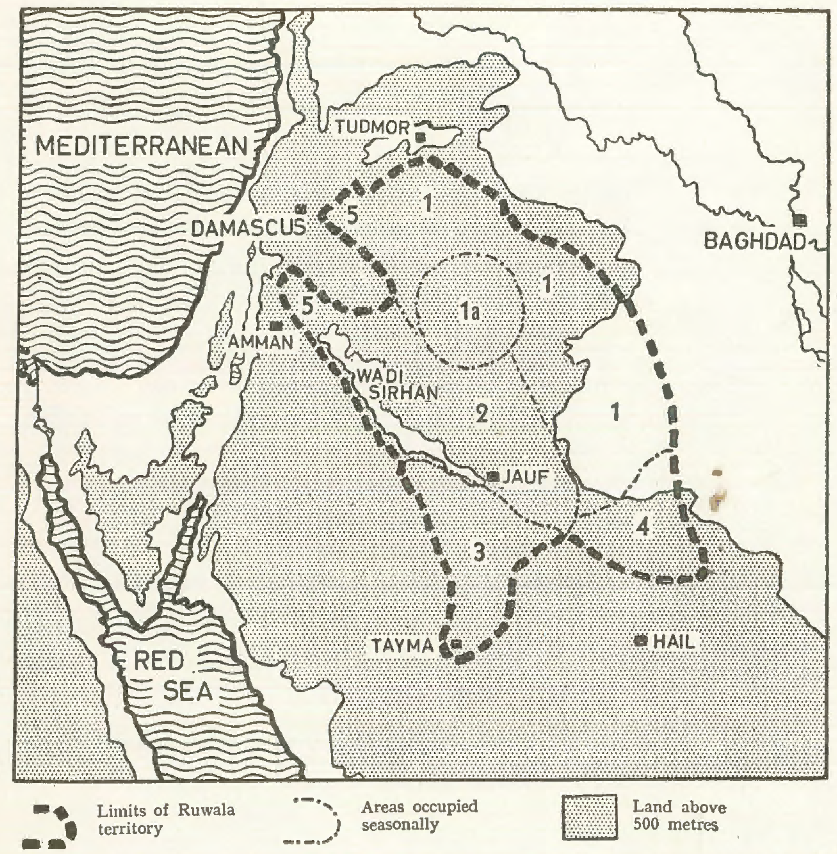

Fig. 1. Source : After C. Daryll Forde : « The North Arabian Badawin », in *Geography* (Sheffield, The Geographical Association), Vol. 18, 1933, p. 209.
The numbers refer to pastures occupied seasonally as follows : 1. Winter (1 *a*. Richest in winter) ; 2. Spring ; 3. Occupied in winter when rains are good or usual pastures fail ; 4. Occupied when pastures fail to the north and west ; 5. Summer (oasis settlements).

Political boundaries between modern States are naturally a handicap to such large-scale wanderings. There is always some agreement between neighbouring countries, however, so that no serious hardships are encountered, except perhaps with regard to the boundaries of Israel [1].

Nomadic tribes in the Middle East are, as already noted, camelherders. Camels constitute their wealth and are a symbol of their social standing. They supply the Bedouin's staple diet : milk and enable him to buy necessities, find the dowry for one or more wives, and pay the *diya* or blood-money. He may possess other animals, such as horses for raids and perhaps some sheep, goats and donkeys. But wealth and importance depend on the quantity and quality of the camel-herds, and in order to have the largest possible herds, all sources of grass and water, no matter how distant, are utilised. This means that the wanderings of the nomads are very extensive indeed.

Some camel-herdsmen used to engage in trade, and carry merchandise across the desert, an occupation which often proved very profitable. Sometimes they themselves owned the merchandise, and sometimes they acted merely as carriers who organised caravans between such centres as Damascus, Mecca, and Aden; or between Tadmor, Baghdad and Samarkand; or, in Africa between Biskra and Timbuctoo. Until fairly recently they used to carry and accompany pilgrims to Mecca, or transport goods under contract for governments or other agencies. Of such regular caravans very little remains; and the only relics of such conditions to be encountered are the occasional itinerant merchants who accompany the Bedouin and sell their goods at different camps along the route. Another type of trading takes the form of driving camels long distances to dispose of them in some profitable market. Such are, for instance, the journeys undertaken by the Kababish from Kordofan in the northern Sudan, who travel about 2.000 miles to bring a few hundred head of camel to the Cairo market, returning home by train and boat.

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[1] See Ahmed Al-Akkam, « The Tribez of Syria », in *Report and Contributions of Scholars in the Fourth Seminar on Social Problems* (hereafter referred to as *Arab League Seminar*) (published in Arabic by the Arab League, Cairo, 1954), pp. 1030-1036.

Semi-Nomadic Groups

Semi-nomadic groups possess few camels. In fact, in countries like Syria and Iraq, the principal distinction between nomads and semi-nomads is that the latter mainly breed sheep. They usually live in huts built of mud and straw, and their mobility is far more restricted. As a rule they carry out a certain amount of cultivation, and may possess date-palm groves or other gardens. The following may be considered a fair description of a semi-nomadic tribe, the Jawabis of the western (Libyan) desert of Egypt :

> The nomadic Jawabis are for the most part still settled in and around Wadi Natrun ... [They are] a hospitable tribe who lead a shepherd's life and encamp there every winter with their flocks. They are employed during this time carrying natrun and prickly reeds; they also have some traffic in dates, which they fetch in caravans from Siwa in the Ammonian Oasis.... These Arabs are *marabouths,* or peaceful people ... they never make war, and only take up arms to defend themselves .... They share with the Awlad ʿAli in the date traffic with Bahariya Oasis, where the produce of the village of Mandisha is reserved for them [1].

These Jawabis represent one type of semi-nomadism whose principal characteristic is that the tribe as a whole engages in various activities which include agriculture in Wadi Natrun, sheep-raising, and several carrying arrangements, including traffic in the date crops of distant oases. They own just enough camels for the last type of activity.

There is, however, another type of semi-nomadism, also common in the Libyan desert, the principal feature of which is that a tribe is divided into two parts, one leading a fairly settled agricultural life, and the other a completely nomadic one, with camel-herding as its main occupation. The two sections maintain a semblance of social unity, having one Sheikh for the whole tribe, but in day-to-day matters the two are quite independent.

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[1] Murray, *op. cit.*, pp. 279 ff.

Settled Tribal Groups

Tribal groups which lead a completely sedentary life with agriculture as their main occupation are very common throughout the Middle East. They have abandoned their wandering life, but retain their tribal organisation. They usually occupy lands in rather close proximity to the desert, their previous « homeland ». This is quite obvious in the Nile Delta, where the eastern and western fringes are mostly settled by tribal agricultural communities. In most instances their conversion to sedentary life has been fairly recent. But this is not necessarily the case everywhere. Some tribes have been settled on the land for a fairly long time, and still continue to maintain their tribal solidarity and refuse to intermarry with the earlier settlers or « fellaheen ». Feuds have persisted between the two sections sometimes for one or two centuries. A good example of this is afforded by the Hawara of Upper Egypt, now mostly in the province of Qena. They at one time dominated a considerable part of Upper Egypt, but though their political power is a thing of the past, they still maintain their tribal cohesion, and refuse to give their daughters in marriage even to a wealthy fellah [1]. The problem of merging the tribal and non-tribal groups may be somewhat different from that of converting the nomads to sedentary life, but it represents a further step in the same direction. Tribal rivalries and jealousies have been disturbing factors, in which a great deal of the less agreeable features of nomadic life have been retained, sometimes even in an accentuated form. Again, the prominence given to local tribal solidarity has often been a handicap in the development of a national spirit and outlook. It is therefore not enough from the point of view of the country's welfare merely to settle the nomads; they must also be socially integrated. This point will receive further treatment in the section dealing with Iraq.

The Nomadic Way of Life

Nomadism, as a way of life, is characterised by simplicity and frugality, and those who practise it acquire the habit of freedom and the dislike

(1) Awad, *op. cit.*, p. 251.

of control and limitation imposed by authority of any kind. Even Sheikhs exercise what little influence they may have over their tribes by means of their character, liberality and hospitality. They begin to acquire greater influence when relations with a central government are established, and the authorities find it more convenient to deal with the head of the tribe. But under pure nomadic conditions the head of a tribe is by no means a despot ruling over its members [1].

Nomads are supposed to roam with their herds over lands which are suited only for nomadic life, where grass only grows in widely separated patches, and where the water supply is so scanty and so difficult to obtain that, although it can be drawn to water the camels, its utilisation for agriculture would be beyond the normal capacities of the nomad.

If the nomad kept stricly to land of this kind he might not present such a very serious problem to other populations. But he has invariably encroached on the land of settled agricultural communities. His « contact » with such communities assumes one of two forms, being either sudden and temporary or prolonged and enduring. The first is characterised by a sudden raid, in the course of which cattle are lifted, grain seized and other property carried away. Such raids are part of the general pattern of nomadic life and are frequently carried out by nomads against each other as well. The raid is led by a special leader, Al-ʿAqid, and in its simplest form may be accomplished at dawn and completed before anybody in the attacked tents or village is aware of what has happened, until he wakes up to find that property is missing [2]. Against such raids the settled agricultural population have very little protection, especially where the country is administratively disorganised.

The more enduring kind of contact with nomads is characterised by more persistant penetration, in the course of which the sedentary agricultural community becomes tributary to some powerful tribe, which exacts a heavy price for protecting the villagers against other nomads. This has frequently led to the emigration of the peasants, and the occupation of their lands by nomadic herdsmen. It this way much agricultural land in the Middle East has become a « nomad's land ».

(1) Murray, *op. cit.*, p. 42. (2) Murray, *op. cit.*, p. 134.

This is particularly the case with lands requiring elaborate irrigation, by means of canals and regulators. But throughout the whole of the Middle East vast areas which legitimately belong to agriculture have been taken over by pastoral nomads. This has always occurred in the absence of a strong central government. As soon as such a government comes to existence, the frontiers of nomadism begin to retreat further and further back towards the original nomad's land.

We thus note that the frontiers of nomadism have undergone considerable fluctuations throughout history, and their expansion has been in direct proportion to the weakness of the central government. It follows from this that nomads as such are not particularly interested in the existence of a strong, firmly established government, and any limitations on their freedom which the authorities try to impose are resented. The normal duties of all citizens, like the payment of taxes and conscription, are specially hated; a deep suspicion of the government and its officials invariably exists in the mind of all nomads, and this takes some considerable time to overcome.

Agriculture is distasteful to the nomad because it deprives him of the freedom so dear to his heart, involves considerable manual labour, which he detests, and forces him to carry out work which he often relegated to his slaves or servants, or to those settled peasants over whom he tyrannised; besides this it is irksome to his free and roaming habits to have to settle down in one and the same spot, and to submit to all the restrictions imposed by government agents of all kinds. G. W. Murray describes the normal life of the Bedouin in the following terms :

> The male Arab is quite content to pass the day smoking, chatting and drinking coffee. Herding the camels is his only office. All the work of erecting tents, looking after sheep and goats and bringing water, he leaves to his women [1].

The pastoral nomad has accordingly been described as exceedingly indolent. Major Jarvis speaks of the Sinai Bedouin in the following terms :

> Suggest to an Arab that he should take a *fas* and put in an hour's work cutting a water-channel to his cultivation, and he will wear the expression of a martyr

[1] *Ibid.*, p. 60.

> going to the stake; and if one takes one's eyes off him for a moment, he will probably fade away with his family to Palestine for a year to escape the task [1].

Other quotations could be given. But with all his indolence the Bedouin could organise and execute a raid, involving exceptional physical hardship and endurance; nor, in all his native festivities and celebrations, does he show the slightest indolence. The problem seems to be that he is indolent when the work is distasteful to him. There is also some evidence in the opposite direction. When visiting Sinai in 1934, Ammar was informed by the European manager of the manganese mines that many Bedouin were employed at the mines, who, after some training, became capable workers [2]. The Arabian American Oil Company (Aramco) employs over 20.000 Arabs, most of whom have a nomadic background.

It may be argued that certain types of gainful occupations, under favourable circumstances, might be quite agreeable to the Bedouin, but that agriculture as a rule is not one of them. Nevertheless there have been many cases where whole tribes or tribal sections have gradually settled down to an agricultural life with all its hated drudgeries, which, in course of time, became less and less hated. This has occurred among both the Beja in the Sudan and the Arab tribes in Saudi Arabia and the Fertile Crescent, while in Egypt the assimilation of the nomads is going on all the time [3].

It seems, therefore, that the conversion of the Bedouin from nomadism to a sedentary life is not impossible of accomplishment. It is also likely that nomadic groups vary in their attitude towards agriculture and that many of them would be more easily persuaded than others. It is probable that the Bedouin who have come into closer contact with settled life would be less reluctant to change their methods and would take more kindly to agriculture. In any case the nomad never turns into a first-class peasant overnight; a little time, sometimes even one or two generations,

[1] Jarvis, *op. cit.*, p. 25 ff. *Fas* is Arabic for a kind of pick. Note that Major Jarvis was referring to a Bedouin who already practised some cultivation.

[2] Ammar, *op. cit.*, p. 188.

[3] Awad, *op. cit.* The whole of this paper should be read in conjunction with the present article.

must be allowed before a purely nomadic group becomes a fairly good agricultural community.

Methods of Encouraging the Settlement of Nomadic and Semi-Nomadic Tribes

It will be clear from the foregoing that no initiative can be expected from the nomads themselves towards their own permanent settlement. The initiative must come from the authority directly interested in such a development, namely the government of the State in whose lands the nomad carries on most of his wanderings.

The first important factor, therefore, in the settlement of nomads, is the existence of a strong central government with an interest in the establishment of peace and order, and in the welfare of the land and all its inhabitants. One of its urgent duties must be to work out a policy for dealing with nomadic groups, usually aiming at their complete or partial settlement. Whether from humanitarian, political, economic, strategic or administrative motives, such a result must be achieved as quickly as possible. Two methods readily suggest themselves : coercion or persuasion, or a subtle mixture of the two. There is little doubt that for lasting and beneficial results persuasive methods are far more effective than any kind of compulsion. Most governments of the Middle East, without in any way overlooking the disagreeable characteristics of nomadism, look upon the nomads more as an asset than a liability, and have initiated definite programmes for their settlement.

The methods which help to bring about the partial or complete settlement of nomadic groups may be classified as indirect or direct.

Indirect Methods

Indirect methods are those which have another objective than that of settling nomads. Among the most important of these is the construction of railway lines, like that extending from Alexandria to the Libyan frontier, from Cairo across Sinai to Palestine, from Atbara to Port-Sudan, and the whole railway development in Iraq. Roads for motor traffic also prove useful, but are not as effective as railways. Many individuals are employed on their construction, including a considerable number of nomads. They help to build railway stations along the route, thereby creating centres of contact, some of which soon develop into public service centres, where a school, a clinic and a weekly market are soon established, and where the authority of the government is more effectively exercised.

The digging of the Suez Canal was never intended as a means of controlling nomads. Nevertheless it has helped to create a ribbon of settled life in the middle of the desert and has limited the movements and inter-tribal raids between Sinai and the Eastern Egyptian Desert.

But by far the most interesting developments in this direction are those connected with the production and transport of oil. The labour for such gigantic undertakings is never made up entirely of nomads, but there is always a large proportion of them, and they thereby become accustomed to regular employment, a settled home, new trades, in addition to the psychological effects, which are difficult to assess, produced by contact with a strong civilisation and its representatives.

The number of native Arabs directly employed in the oil industry hroughout the Middle East may reach about 50.000 to 60.000. In addition there are large numbers of small tradesmen, workers and others employed in auxiliary duties, and rendering services to the oil communities. Again, the prosperous governments and their agencies have several undertakings involving the large-scale employment of labour, so that the impact on the population must not be measured solely by the number of the individuals directly employed by the oil concerns.

Another important result of the oil operations has been the realisation that, in the desert, oil is not the only valuable liquid. The companies have therefore given special attention to the tapping of any water resources which can be found anywhere in the area of their concession.

Thus both government and commercial enterprises, whose operations may not be directly concerned with the problem of the settlement of nomads, have helped considerably, though indirectly, towards its solution.

Direct Methods

There are, however, special schemes which are directly concerned with helping the nomads to lead a sedentary life, or at least a less nomadic one.

The nomads themselves could not, even if they wished, carry out any schemes of this kind, which must remain the main concern of the public authorities of each country. These schemes aim, in the first place, at providing water for agriculture. The water resources remain the same, and cannot be increased; but they can be stored or tapped, and made available for cultivation at the proper time and in the most effective manner possible. The storing of river water at flood time for subsequent use for irrigation has been the most important undertaking in this respect throughout the Middle East, and has produced the greatest results. The rivers whose water is dammed up and stored, are sometimes of a fair size like the Tigris and Euphrates and their tributaries, or rather small like the Khor Baraka and the Khor-al-Gash in the Sudan. Sometimes even desert wadis in which flooding takes place somewhat irregularly, like the Wadi-el-ʿArish in Sinai, can be utilised in the same way, though of course on a much smaller scale.

Another source of water for cultivation is the scanty rainfall which is characteristic of the southern Mediterranean coastal belt, from 15 to 30 miles wide, stretching from Libya to Palestine. Another area with scanty rainfall is eastern Syria, Jordan, northern Iraq and parts of Saudi Arabia. Both in Libya and in Sinai, a rainfall ranging from 4 to 8 inches on the coast makes it possible for some grass to grow, but most of it percolates through to the lower layers, where it mingles with the sea-water seeping through the sand. The fresh water, however, lies in a layer above the salt water and, where a large subterranean cavity exists, substantial quantities of fresh water are stored and easily tapped. In this way, fairly large settlements, like Borg-el-Arab, Marsa Matruh, Sallum and ʿArish, are able to grow and prosper. These subterranean waters were already utilised in Roman times, but were subsequently neglected, until their modern revival. They are now being more

extensively developed by oil-driven and wind-driven pumps. The latter method is gaining favour now; the regularity of the trade-winds is an important consideration; the cost is small and one wind-pump is considered adequate for the irrigation of 5 acres of land; and as it requires little maintenance, or mechanical skill, it seems best suited to the Bedouin's temperament.

In addition to river and rain, there are of course wells and springs, scattered throughout the desert, which are apparently independent of both rain and river. Some springs actually burst out of the rocks, and one such spring might be adequate for the irrigation of 20 or 30 acres. But most wells are of the deep variety, and need some power for bringing their water to the surface. Only when their water is abundant can such wells be utilised for cultivation.

The oases in the heart of the desert usually occupy depressions, with an adequate water-supply from springs and shallow wells. They constitute areas of sedentary life, where agricultural communities have been in existence for many centuries. In time of weak central governments these communities are exploited and black-mailed by the nomads. Many of their villages were built in the form of large fortifications, though this availed but little. They often became vassals, tributary to some powerful tribe. At one time even the Faiyum, so close to the centre of government in Cairo, suffered the same fate.

Some nomadic groups claim ownership of certain oases, and what cultivation there may be is carried out by their slaves or servants.

The most successful governments have found it necessary not only to provide water but also a certain measure of education. This does not merely refer to learning the «three R's», however desirable this may be, but also to learning methods of dry farming and other ways of conserving water resources; for, contrary to what might be expected, the Bedouin becomes very wasteful when he sees large supplies of water provided without any effort on his part.

The provision of school education for the children of nomads during their wanderings is still in the experimental stage. Tribes seldom wander in sufficiently large numbers to justify the provision of some kind of travelling school, though there have been some attempts in this direction.

Some have as part of their organisation a « mullah » or learned man, who is versed in the history of the tribe and its laws and traditions. He often acts as liaison with the authorities [1]. But since there is only one such distinguished individual in a tribe, which may be on the move in small separate groups during nine months of the year, he can hardly be expected to fulfil the additional duties of instructor.

As contact has, however, been established almost everywhere between the Bedouin and the agencies of modern governments, the benefits of state-sponsored education have been brought to the notice, and within the reach, of almost all the tribes. Those who wish to benefit by such facilities can perhaps find room in a boarding school, or leave their children in the care of some of their relatives who lead a less wandering existence. Recent statistics published by the Frontiers Administration of Egypt show that school attendance in Sinai, for instance, amounts to 8000 boys and 1100 girls (total population 50.000). Although the schools tend to be concentrated in large centres like 'Arish, they are sufficiently dispersed throughout the Sinai Peninsula to be within reach of all the tribes. There is, however, no information on the extent to which nomads make use of such education, beyond a general statement that « Bedouins have begun to send their children to the schools in large numbers, despite their general poverty » [2].

The settlement of nomads throughout the Middle East is thus being brought about by direct and indirect methods. Progress has not been made everywhere at the same rate. Fairly quick results have been achieved in lands which, until fairly recently, were devoted to agriculture, and where water resources are abundant. In other cases progress has been slow and characterised by a transitional stage of some kind of semi-nomadism. In such cases the Bedouin divides the year into two parts : one for wandering and the other for some kind of cultivation. He will prepare the ground, sow the seeds (usually provided free by the government), and then depart with his flocks for a few months, returning later for the harvest.

(1) See Abdul Jalil Al-Tahir, *Bedouins and Tribes in Arab Countries* (in Arabic) (Cairo, The Arab League, 1955), p. 17.

(2) See *Report of the Frontiers Administration, Egypt* (1957), especially pp. 25 and 32.

But even the Bedouin must realise by now that nomadic life has no longer the same « attractions » it used to possess. The freedom it conferred has been severely curtailed ; the nomad can no longer raid a neighbouring or distant camp or attack a caravan while the authorities are maintaining their usual vigilance. He sometimes protests that the desert is his own land to do with it what he likes ; but he does not dare to persist in such a claim. His Bedouin code is no longer allowed to govern the affairs of the nomads, either among themselves or with their neighbours. Any case of murder, theft or crime of any kind is dealt with by the competent state authorities, which apply laws specially enacted to meet desert conditions. In some countries they may still allow tribal committees to judge special minor cases, but a member of the state administration is always present at such committees. Little wonder then that the number of nomads has been drastically reduced in the last fifty or sixty years, until it can scarcely exceed 1 per cent. of the total population of the Middle East.

Problems Following Settlement

As previously indicated, no matter how desirable it may be to settle the nomads, they continue for some time to present certain problems to the State even after they have ceased to wander.

Because a tribe is usually settled in a well-defined piece of land, it is able to maintain its original unity and some at least of its social institutions. For a considerable number of years the tribe does not merge with the rest of the population. Some of its social institutions, such as the habit of marrying a young woman to her paternal cousin, are harmless enough. This custom is so deeply rooted, that no girl can possibly accept an offer of marriage, even from a distant relative, until her cousin, the son of her paternal uncle, has given his consent. One of the interesting results of this persistent in-breeding is the close physical similarity of all members of the same tribe. « The Sheikh of Muzaina says he has only to look at a Sinai Arab to be able to say which tribe he comes from » [1].

(1) Murray, *op. cit.*, p. 35.

But a first cousin represents only a man's first wife; for his second, third or fourth he usually goes farther afield, because the males have the liberty to take as their wife even a daughter of the despised fellaheen, whereas their own daughters could never be given to a fellah.

More objectionable habits, however, also persist, such as blood-revenge, feuds, and a lack of respect for the property of neighbours. But the most serious problem in the recently sedentarised Bedouin society is the growth of the power of the Sheikh, or head of the tribe. For reasons of convenience the state authorities often decided to deal directly and solely with the Sheikh. The land for the tribe was handed over to him, and he often considered it, or most of it, as his sole property. He became a kind of feudal lord, wielding considerable influence over his tribe. He exacted implicit obedience from all its members, though he usually mingled such despotism with some acts of generosity and hospitality. The solidarity of the tribe rather increased than diminished under sedentary conditions; and loyalty to the State occupied only second place to tribal loyalty. It sometimes happened that an ambitious Sheikh, turned politician. was able to exercise such political powers that he was able to bring about a change of government [1].

Such a state of affairs represents a kind of «feudal phase» which is already on the wane and cannot survive the inevitable growth of national consciousness.

NOMADISM IN THE COUNTRIES OF THE REGION [2]

Egypt

The principal inhabited area in Egypt is the Nile Valley, about 35.000 square kilometres in area or 3.5 per cent. of the total area of Egypt. The rest is desert and semi-desert. The Nile Valley supports a population

[1] Al-Tahir, *op. cit.,* pp. 45 and 55. The author gives a detailed account of the disruptive activities, in the form of political agitations, of certain Sheikhs of Iraq in 1934 and 1936, and the rebellions which they instigated in Diwaniya and elsewhere.

[2] See also the appendix to the present article in which the effects of land reform on nomadism in Egypt, Syria and Iraq are discussed.

of over 20 million, while the vast deserts have barely 500.000, mostly settled in towns and villages, either in the many oases or in the centres of administration or mining. The nomads are officially estimated to number about 55.000. As elsewhere in the Middle East the tribal or «Arab» population is very much larger than the purely nomadic. In the census for 1907 special mention was made of «tribal Arabs» numbering about 600.000 out of a population of 11.287.000; but this practice was discontinued in subsequent censuses, probably because there was no purpose in stressing a distinction which was gradually disappearing.

The nomadic population of about 55.000 is half what it was in 1907, and consists at present of «tribal sections» only, since there is no tribe at present which is wholly nomadic. This great reduction is due to the fact that the Government has been actively concerned with the problem of nomadic and tribal groups for the last 150 years. The result is evident in the conversion to intensive cultivation of many districts that were traditionally part of the nomads' territory. The most notable example is the eastern Delta including the Wadi Tumilat (the ancient Land of Goshen), which from time immemorial was the home of wandering tribes. The same is true of the western Delta, whose western districts are largely inhabited by tribes of Libyan origin [1]. The establishment of the Suez Canal Zone has created a broad ribbon of settled life in the heart of the Eastern Desert, from which the nomadic population of Sinai and of the lands west of the Canal have drawn substantial benefits.

In Egypt the areas of interest for the study of nomadism and semi-nomadism are (*a*) the Western or Libyan Desert, (*b*) the Eastern or «Arabian» Desert, and (*c*) Sinai.

The Libyan Desert.

The Libyan Desert is a land of great aridity almost completely lacking in water resources except in three areas, namely the northern fringe,

[1] Awad, *op. cit.,* pp. 240 ff. Tribes from Libya usually settle west of the Nile, and those from Asia settle in the eastern districts of the Delta. The only exception is the Hanadi, a Libyan tribe, who were invited by Mohamed Ali to settle in Sharqiya Province, to terminate their feuds with the Awlad ʿAli.

extending along the Mediterranean, a string of oases in the northern sector called Siwa, Bahariya and Farafra, and a string of large oases in the southern sector, called the Kharga and Dakhla Oases. These oases are areas of settled cultivation and are no longer exposed to the raids of nomads.

Thus, for the purpose of the settlement of nomads, the only interesting area is the land bordering on the Mediterranean. This region is reputed to have been quite fertile in Classic times, and a great effort is being made at present to recover its old prosperity. A railway line with a daily service from Alexandria to Sallum has helped in supplying many services to the scattered population. The principal tribal groups are the Awlad ʿAli, by far the most widely spread throughout the whole area. Other tribes with a more limited range are the Jumeiʿat around Mariut, the Jawabis in Wadi Natrun; and the Samalus, who are rather dispersed throughout the whole area, with some sections completely settled in the Faiyum and Upper Egypt. None of these tribes is now wholly nomadic, though some sections continue to wander with their camels.

There are at present several projects offering opportunities for further settlement. The small rainfall is being utilised to the utmost, and the water that percolates underground is tapped and brought back to the surface by wind-pumps. Experiments are being successfully carried out for providing new drought-resisting varieties of grass for raising new selected varieties of sheep. The Ministry of Agriculture is encouraging the cultivation of the fig, the olive and the vine. A summer resort is attracting thousands to the extensive beaches of Marsa Matruh; Wadi Natrun is being intensively developed as an agricultural, sheep-raising and mining centre. In all these projects the Awlad ʿAli and the other tribes are fully participating and drawing considerable benefits. They cultivate, in addition, several scattered gardens which supply the markets of Matruh and other centres with vegetables and fruit. It is also alleged that many of them benefited from the Second World War by rendering services to the troops; the only remnant of such activity at present is their employment in clearing the area of mines and hand-grenades.

It will be noted that there is no project for settling a nomadic group in any of the oases. Such a course would be unwelcome to both the

tribes and the sedentary oasis population and unnecessary friction would result. The policy followed in Egypt and elsewhere in the Middle East is that the nomad should be settled in his own environment, by providing all possible inducements there.

The Eastern Desert.

The Eastern Desert extends from the Mediterranean borders in the north to the Sudan frontier in the south, and from the Nile to the Red Sea. It may be usefully divided by a line extending from Cairo to Suez, along which a railway line and a first-class road run. The land to the north of this line, once an important nomad's area, is now part either of Sharqiya Province or the Canal Zone, both areas of intensive cultivation. The number of those pursuing a nomadic existence north of the Suez-Cairo railway is insignificant.

To the south of the Suez-Cairo line, however, some nomads still exist. The province, which is known as the «Red Sea Governorate», has a population of about 20.000, the vast majority of whom are workmen, mostly from Upper Egypt and the Canal Zone, employed in the different mining enterprises. The rest of the population, whose number is not given, but should not exceed a few thousands, consists of Bedouin tribes, known as the Maʿaza in the north, the Guhaina in the centre, and the ʿAbabda in the south. How many of them are employed in the different enterprises is not known, probably very few. They practise little agriculture and feed their camels, sheep and goats on the scanty grass patches in the innumerable wadis traversing the plateau, and the Red Sea Hills.

The Red Sea coast south of Suez, however, has recently witnessed a considerable growth of population, due to the development of the oil and other minor mining industries. But the oil industry, though nearly adequate for the needs of the country, is not sufficiently large to create any large settlements like those of the Persian Gulf. Although accurate information is not available, however, it must be assumed that the Bedouin have drawn some benefits from the increased prosperity of the province.

Sinai.

Sinai has many tribal groups most of which lead a semi-nomadic life. At one time they engaged in conducting caravans for trade or for the pilgrimage to Mecca. In those days there was no Suez Canal, or any political boundaries between Cairo and Mecca. Each tribe along the route made some profit and the incentive to agriculture was small. Such activity is a thing of the past. Both the Suez Canal and the Palestine boundary have helped to confine the tribes to Sinai itself. The 17 different tribes enumerated by Murray are all of Asiatic origin [1]; and many of them are related to tribal sections in Palestine. Jordan and Saudi Arabia on the one hand, and to the settled or semi-nomadic tribes of Sharkiya Province in the Eastern Delta of the Nile on the other. Very little intercourse between the different sections obtains at present.

It is safe to say that hardly any tribe of Sinai can at present be described as totally nomadic, although few of them engage in agriculture with any great enthusiasm. In this respect Sinai is usually divided into three sections—a northern, a central and a southern. The northern section is the area of greatest settlement and contains about half the total, population of Sinai [2]. There are important centres of settlement in El ʿArish, the capital, and Rafah, on the eastern border, in addition to smaller centres of cultivation which depend on the winter rains and the pumping of underground water. An additional income is obtained by catching quail along the seaboard and fish from Lake Bardawil. Through this area runs the Palestine Railway, and the inhabitants live mostly in permanent dwellings.

In the central area, dominated by the Tiyaha and Haweitat tribes, there is some uncertain rainfall which gives little incentive to cultivation. In addition there are some running springs, and some torrents tributary to the Wadi-el-ʿArish. With the help of the State both these sources

[1] MURRAY, *op. cit.*, p. 247.

[2] AMMAR, *op. cit.*, p. 158. Also the Egyptian Statistical Book for 1956. No reliable figures are available for separate tribes. AMMAR, quoting SHUQAIR, gives figures ranging from 12.000 in the northern favourable section, to 2.000 to 4.000 further south.

have been utilised; and some Tiyaha are engaging in agriculture in a fairly regular manner. Progress must necessarily be slow and, moreover, much of the work accomplished was destroyed during the hostilities of 1956.

The southern area lies south of a line extending from Suez to the head of the Gulf of Aqaba. This part is indeed the Peninsula proper, and contains the famous Monastery and Settlement of Saint Catherine, which date from the time of the Emperor Justinian. This settlement depends mostly on water from springs and wells for its crops of grain, vegetables, fruit trees and date-palms. The same is true of some other limited areas like the Wadi Feiran, and in all these instances a substantial settlement of nomadic groups has been effected. The rest continue their pastoral pursuits. Many have, however, found employment in the different mining interprises, notably in the oil-producing plants near the Gulf of Suez and the manganese mines near Abu Zuneima.

The Sudan

At least the northern part of the Sudan, with its Caucasian population and Arabic-Islamic culture, should be included in the Middle East. It is also a country which offers many interesting features regarding tribal life. Most of the inhabitants belong to a clear tribal pattern whether they practise cultivation or lead a semi-nomadic life. It is rare to meet a Sudanese who does not take pride in belonging to one or other of the tribes living on the banks of the Nile, or west of the river in the provinces of Kordofan and Darfur, or east of it as far as the Red Sea. Many tribes lead a completely sedentary life with permanent homes, but many also lead a partly sedentary and partly nomadic life. Love of their herds and of the life of wandering is too dear to their hearts to be quickly discarded. It is nevertheless quite evident that considerable progress has been achieved in the growth of cultivation and of sedentary life, both among the Arabian tribes and among the Hamitic Beja.

The Arabian tribes of southern Kordofan and Darfur have had to abandon camel-breeding, the savanna proving unsuitable for the herds; they have taken to breeding cattle, and have come to be known as the

Baqqara [(1)]. They practise agriculture as well and have fixed homes, where part of the tribe always remains when another section moves with the herds.

North of the 12th parallel of north latitude lies the domain of the camel-breeders, who must travel large distances to the north in order to utilise every available patch of grass. One of the most famous of these, the Kababish, wander sometimes almost to the Egyptian boundary. They have, nevertheless, their settled villages and even their « capital » at Bara, in the less dry area to the south. In these districts considerable numbers practice agriculture and possess large flocks of sheep. Thus even the Kababish must be reckoned as only semi-nomadic, and this is equally true of nearly every other pastoral tribe in the Sudan.

East of the Nile and along the Red Sea Hills live the Beja, the breeders of perhaps the finest camels to be found anywhere. They comprise four large tribes; the Bisharin, part of whom live beyond the Egyptian boundary, the Amar-Ar, the Hadendawa, and the Beni-Amer, partly settled in Eritrea. All these tribes practice both pastoralism and agriculture, the proportion of pastoral nomads being greatest in the north and least in the south, in accordance with the distribution of the rains.

There have been some large irrigation projects, notably in the Gezira between the White and the Blue Niles, in the Gash Delta, near Kassala, and at Tokar, near the Red Sea, where the flood of the Khor Baraka is utilised for irrigation. All these projects have led to a considerable increase of the agricultural population, whether Arab or Beja, with opportunities for the spread of education and the learning of new arts and crafts [(2)].

Syria

When Syria was under French mandate, the problem of the nomads was in the hands of an officer stationed in Beirut. The mandatory

[(1)] Arabic word for those who breed or own cows.

[(2)] For a detailed account of the tribal groups in the Sudan see Mohamed AWAD, « Diffusion of Arab Influences in the Sudan », in *Bulletin of the Geographical Society of Egypt,* 1953, Vol. XXV.

authorities, having perhaps too much on their hands in other fields, did not attempt to draw up any special policy for the nomads, who at that time consisted of 60 tribes of about 350.000 souls or 10 per cent. of the total population.

When Syria became an independent sovereign State, a definite policy to deal with the nomads was started and was even included in the Constitution of 1950, article 158 of which contains the following provisions :

(1) The Government shall endeavour to sedentarise all nomads.

(2) A special law shall be enacted to regulate the affairs of the nomads, until their sedentarisation is completed.

(3) A plan for the gradual settlement of Bedouins shall be drawn up, and shall subsequently be embodied in a special law, with the necessary budget for its execution.

(4) In the electoral law special provisions shall be included to meet the special circumstances of the nomads and make it possible for them to elect their representatives in Parliament.

Thus the sedentarisation of nomads became part of the Constitution of the Land. The law for the regulation of Bedouin affairs, referred to in article 158 of the Constitution cited above, was enacted on 21 May 1953, and created the machinery necessary for dealing with the affairs of nomadic and semi-nomadic groups. While the head of this machinery is still the Minister of the Interior, whose ruling is required for any major decision, a senior officer in the same Ministry is in charge of a special department of nomadic and semi-nomadic groups, with branches in all provinces, and guard-stations in the nomadic areas. The tribal groups throughout the land were urged to engage in cultivation and build more permanent homes; many nomadic groups responded and became at least semi-nomadic, while those classed as semi-nomadic became almost completely sedentary. Whenever a semi-nomadic group became sedentary its name was crossed from the register of the semi-nomads, and it became an ordinary settled community. The number of purely nomadic tribes has been reduced to eight; their names are given below in four groups of two tribes each according to their locations in Syria, irrespective of their wanderings elsewhere :

(1) The Ruwala and the Hassana, of the Syrian Desert.

(2) The seven Butainat and the seven ʿAbadah, in the neighbourhood of Tadmor.

(3) The Fadʿan Walad and the Fadʿan Kharsah, in the desert bordering the Euphrates.

(4) The Shammar-al-Zur, and Shammar-al-Kharsah, in the neighbourhood of Deir-ez-Zur.

The number of these nomadic groups is estimated to be about 150.000 [1].

It seems certain that quick results in sedentarisation were achieved in Syria, for we learn from a reliable source that the Jezirah in north Syria has become the country's principal granary. Once the home of roaming warlike Bedouins, it was pacified and thrown open to agriculture only during the last two decades. Beginning in the Second World War cultivation was rapidly expanded, until now the Jezireh produces half the country's wheat, and a considerable amount of barley as well [2].

The «home» of the nomads of Syria lies in the eastern and north-eastern districts, so that a certain part of the country is designated as «Badia» or land of the Bedouin and a line could be drawn delimiting the extent of this territory. Although the area has been steadily shrinking as more and more groups have become sedentary, the conception is nevertheless useful and has a practical application, for the Bedouin can enjoy his legal privileges, the most important of which is his right to carry arms, only as long as he lives in the Badia. Once he crosses the boundary, he must get a special permit in order to keep his gun just like any other citizen, and must submit in all other respects to the exigencies of a settled sedentary life.

The central authority responsible for tribal affairs is kept informed of all developments, by means of guard-stations set up in different parts of the Badia, well equipped with telephones for rapid communication. These guard-stations are not installed for «controlling» the nomads

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[1] Al-Akkam, *op. cit.*, p. 1021, and International Bank for Reconstruction and Development, *The Economic Development of Syria* (Baltimore, Johns Hopkins, Press, 1955), p. 4.

[2] International Bank for Reconstruction and Development, *op. cit.*, p. 8.

or their movements, but for assistance and rendering medical and other services. They are also the agencies which assist in carrying out any public duties, such as the election of the ten members of parliament assigned to the Badia.

As an example of the services rendered, the question of giving education to the children of the Bedouins is specially interesting and one in which Syria is carrying out real pioneer work. Six boarding schools, exclusively for the children of nomadic groups, have been set up in different parts of eastern Syria not far from the Syrian home of the nomads. In these schools the children are given their primary education, food and lodging free of charge. A further experiment worth watching with great interest is the provision of «tent-schools» with teachers to accompany the Bedouins during their wanderings. It is unlikely that such experiments would have been attempted unless there was some demand for them.

The Syrian authorities are not relaxing their efforts to complete the process of settlement of their nomadic groups. The next great step is concerned with large irrigation works on the Upper Euphrates, which should supply sufficient water for irrigating a considerable part of the Syrian section of the valley of that river, which is mostly nomadic land at present. It seems there is every reason to believe that the policy of Syria for solving nomadic and tribal problems and winning more and more of them for sedentary life is destined to achieve further successes.

Iraq

The population of Iraq, numbering about 5 million, is divided, according to one authority [1], into—

(*a*) nomadic groups : 8 per cent.;

(*b*) tribal groups (sedentary) : 48 per cent.;

(*c*) non-tribal peasants : 22 per cent.;

(*d*) city dwellers : 22 per cent.

This would give a nomadic population of nearly 400.000, which is probably an overestimate. Official and semi-official sources put the

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[1] Al-Tahir, *op. cit.*, p. 78.

figure at between 200.000 and 250.000 [1]. However, the remarkable feature of the population problem in Iraq is the extremely large proportion of tribal groups, which constitute more than half the population. At present they are, it is true, mostly sedentary; but not very long ago the majority of them did very little by way of cultivating the rich soil of a country which was the home of the most ancient civilisation based on agriculture. This must be borne in mind when we consider the gigantic task which modern Iraq had to face.

All Iraqi authorities agree that this encroachment of nomads followed the Mongol invasion of the thirteenth century, which upset the system of irrigation and inflicted much hardship on the peaceful peasant population. The dislocation of the basic economy of the country led to the incursion of nomadic groups from Arabia, which continued to increase in number and intransigence. Nor did the substitution in the sixteenth century of Ottoman Turkish rule for Mongol rule bring any amelioration. The authorities in Constantinople were too distant and too indifferent and their representatives in Baghdad too weak to challenge the authority of the Sheikhs of the large tribes, who wielded the real power in their respective areas. At best the Turkish authorities were content to allow every Sheikh to rule his province, provided he agreed to collect and deliver taxes. This gave the Sheikhs great authority and made them real feudal lords.

It is probable that elements of the original peasant population joined and became part of the tribal groups as a means of gaining protection and prestige. It was such elements that continued to have a certain interest in the cultivation of some portion of the land; for even at the worst times the tribal lands continued to produce some crops for feeding men and flocks.

The spread of pastoral tribes in Iraq was not confined, as in Syria, to one section of the country. Since the whole of Iraq is close enough to the desert to feel its influence, it is not surprising to find that tribal lands are widely distributed throughout the whole country, though the southern provinces have a greater share.

[1] International Bank for Reconstruction and Development, *The Economic Development of Iraq* (Baltimore, Johns Hopkins Press, 1952), p. 126.

It is thus clear that the roots of feudalism were deeply planted in Iraq, where each tribe occupied an ill-defined area, was always in dispute with other tribes, and was controlled by a despotic chief, to whom alone it owed allegiance. They did not possess any legal title to the lands they occupied, and boundaries were always contested. Few lands, throughout the whole of Iraq, were properly surveyed and registered.

The problem was thus not merely to settle the tribes in the lands they occupied but also to carry out a thorough cadastral survey in order to define the limits of each area claimed. Hasty reforms, like that introduced by Madhat Pasha in 1870, which aimed at giving the tribes the land they occupied, failed completely because no attempt was made to define the limits of each tribal territory.

Conditions began to improve after the First World War. The great Sheikhs, though still feudal lords, became leaders of political parties, members of parliament, and even cabinet ministers. The tribal spirit was somewhat abated by the national struggle for independence, in which the tribal groups participated. In due course lands were reclaimed for cultivation, irrigation canals were cleared, large pumping stations were set up along the rivers, new irrigation projects were planned, and tribal lands were increasingly brought under cultivation.

A most important measure, however, was the gradual and accurate surveying of the whole land, so that it became possible to define estates, tribal and other territories, and to issue exact titles for the ownership of agricultural land. Two laws were enacted in 1932 and 1938, which gave an accurate classification of all lands, whether privately owned, or endowed, or state-owned (by far the largest category), and laid down the rules and conditions for land transfers. « The result of the application of these and other laws» to quote one Iraqi authority «was the establishment of peace and order among the different tribes, and the settlement of nearly all the disputes relating to the ownership of land. This in turn led to the great advancement of agriculture» [1].

[1] See Hassan Mohamed Ali, « Distribution of Land in Iraq and Its Effect on the Development of Agriculture», in *Arab League Seminar, op. cit*, p. 236.

But even under the new reforms the heads of tribes continued to acquire the lion's share of all tribal lands; and ownership of estates of 10.000 acres or more remained a common feature of land tenure. Conditions of tenancy were often so unfair that peasants preferred to emigrate to the towns, where wages were more attractive [1].

The problem began to receive due attention in the years following the Second World War, when a decree was issued establishing a new scheme known as the Dujaila Project, by which reclaimed lands, amounting in the initial stage to 70.000 acres, were distributed among 1.500 small proprietors. This pilot project was completely successful and was followed by similar projects, though on a rather smaller scale.

Apparently the policy of giving most state-owned lands, recently reclaimed, to small peasant-proprietors, was aimed at neutralising any agitation for the breaking-up of large estates. The following statement occurs in the report on the economic development of Iraq by the mission of the International Bank for Reconstruction and Development [2] :

> On the whole the Dujaila scheme has been conspicuously successful. There is no doubt that the settlers who formerly were poor sharecroppers are now far more prosperous and contented. Most of them are obviously proud of their accomplishment...
>
> If [new lands are] reserved for settlement by small-holders, they will make a significant contribution to the social and political stability of Iraq. They may make any strong demand for radical land reform unlikely in the areas now already under cultivation...

Nevertheless, there has been persistent talk of land reform in Iraq, aiming at the limitation of estates owned by one person, somewhat on the lines of the Land Reform Law of 1952 in Egypt.

The purely nomadic tribes comprise about five tribal groups, most of which have branches in Arabia or Syria, though each branch leads a completely separate and independent existence. These groups are—

[1] AL-TAHIR, *op. cit.*, pp. 110 and 111. The author mentions that some estates approach half-a-million acres, not all cultivated.

[2] *The Economic Development of Iraq, op. cit.*, pp. 267-268 and 271.

(1) The Shammar, by far the largest of all. Although important branches live in Syria and Saudi Arabia, the largest section lives in Iraq.
(2) The Sinjara, partly in north-western Iraq and partly in Nejd.
(3) The Zawba, mostly east of the Euphrates.
(4) The ʿAbda, mostly west of the Euphrates.
(5) The ʿAnaza sections, scattered mostly to the west of the Euphrates.

There are two main wandering areas in Iraq—the lands between the Euphrates and the Tigris, and those to the west of the Euphrates. East of the Tigris there is very little nomadism, although some sections of Shammar migrated to the north-east of Baghdad at an early date.

While the Iraqi authorities are deeply concerned with the larger problem of the settled tribes, which constitute nearly half the population, they have not neglected the welfare of the nomads. The main service rendered has been the digging of some 175 deep wells with elaborate facilities for obtaining water without polluting the wells [1].

This section cannot be concluded without reference to the fact that Iraq is the third largest oil-producing country in the Middle East, and that this has had a great direct and indirect influence on tribal settlement. The large oil royalties have certainly helped the promotion of irrigation projects as well as the development of industry, both of which have been great factors in the increased prosperity of tribal groups.

Saudi Arabia

Space does not permit of even a brief survey of the Arabian Peninsula the traditional home and « reservoir » of Arab nomadism. But we cannot avoid some treatment of the kingdom, which embraces most of the peninsula and which, even before it became an important oil-producing country,

[1] AL-TAHIR, *op. cit.*, p. 85, and Abbas AZZAWY, *The Tribes of Iraq* (published by the author in Arabic, Baghdad, 1937), Vol. I, p. 203. It has not been considered necessary to make any reference to the Kurdish peoples living in villages and towns in the north-east provinces of Iraq, although they are sometimes mistakenly described as tribal and nomadic. Actually they live in villages and permanent dwellings and, although some individuals move with the flocks for higher grazing in the hills, this movement is similar to what occurs in the Alps.

was a great political entity extending from the Persian Gulf to the Red Sea and from the Yemen in the south to Jordan and Iraq in the north. It does not consist entirely of desert. Only two great desert areas exist, namely the Robᶜ al Khali (the Empty Quarter) in the south and the Nefud in the north. Otherwise centres of settlement are sparsely or closely distributed in Nejd in the middle of the country, Hejaz and ᶜAsir on the Red Sea, and on the Persian Gulf. There are some winter rains in the north and summer rains in the south, and considerable underground water which sometimes supplies large gardens of fruit and fields of barley, and forms scattered oases in Hejaz, Nejd and elsewhere.

The House of the Saudis belongs to the great ᶜAnaza tribe; and the tribal section to which it belongs is known as Al Masalikh, whose present home is in Syria in the neighbourhood of Homs [1]. But it had already established itself in Nejd in the eighteenth century, when its chiefs co-operated with the great Islamic reformers, the Wahabis.

The population of Saudi Arabia is variously estimated at 3 to 6 million. The truth is probably nearer to 5 million, distributed over more than 1 million square miles [2]. The vast majority of the population, probably no less the 80 per cent., belong to one or other of the many tribes, numbering about 100 and differing greatly in size and in the degree of sedentarisation. Wholly nomadic groups probably do not exceed 250.000. The movement towards a more settled and sedentary life characteristic of the last 100 years was the result of a combination of factors, the most important of which was the religious reforming zeal of the Wahabis, combined with the administrative acumen of the Saudis. The religious aspect is evident in the name given to the new type of settlement, Al-Hijra, which is the word used for the hijira or immigration of the Prophet Mohammed to Medina in the seventh century. These Hijras consist of a kind of oasis, where permanent dwellings have been built and a life of agriculture is pursued. Each Hijra has, of course, its

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[1] See Hafiz Wahba, *The Arabian Peninsula in the Twentieth Century* (in Arabic) (Cairo, The Taᶜleef Press, 1935), p. 243.

[2] See K. S. Twitchell, *Saudi Arabia* (Princeton, University Press, 1953), p. 81.

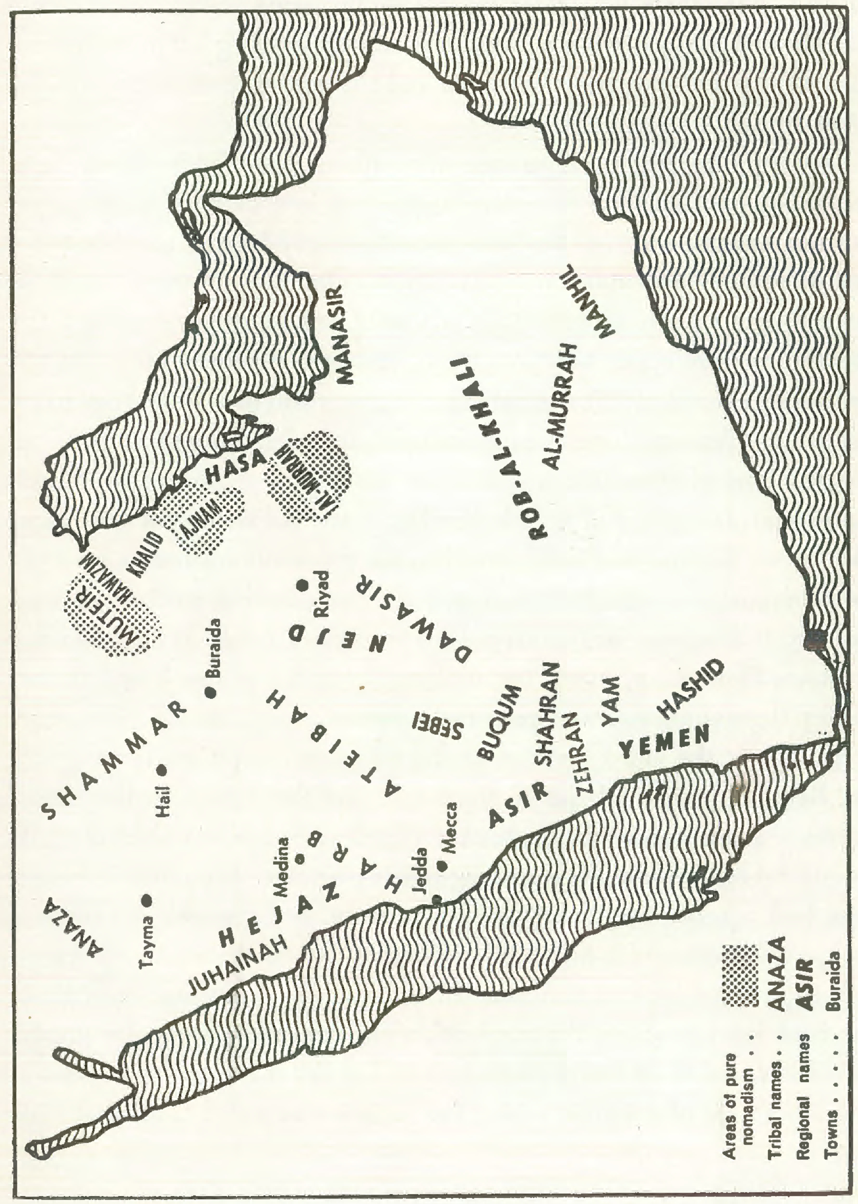

Fig. 2. Sketch map showing the principal tribes of Saudi Arabia.

own name and there are about 200 of them, mainly in Nejd and adjacent lands. Some of them are quite respectable little towns with about 20.000 inhabitants [1]. Older centres in the same region, like Riyad, Buraida and Hail, have experienced a similar rapid growth, enhanced no doubt by the activities of the State and the general prosperity brought about by the oil industry.

The Hijra movement is unique throughout the Middle East, both because it is of an entirely native inspiration and because its principal aim was not the settlement of the nomads simply for the usual benefits that accompany sedentary life, but in particular as a means of enabling them to live a truly religious life. It is of course well-known that the observance of religious practices is not among the salient points in the Bedouin's character. The result of the movement has been that many tribes like Tameem have become completely sedentary and Nejd is no longer a land of nomads.

In Hejaz, the cradle of the Muslim Faith, the old centres of settlement like Mecca, Medina and Tayif have become great administrative centres; their populations have increased and the surrounding gardens of fruit and vegetables have been enlarged. The port of Jedda has witnessed a great transformation, being the diplomatic capital of the Kingdom and a busy thoroughfare in the pilgrimage season.

Al ʿAsir is the third division of the Kingdom, lying on the coast of the Red Sea between Hejaz in the north and the Yemen in the south. It has a summer rainfall of about 12 inches, and a new revival of its traditional agricultural life is making steady progress. Even the « nomads » here lead a very restricted type of nomadism, being mostly breeders of sheep and owners of a fine breed of horses.

Last but not least of the four divisions of the Kingdom, is Al-Hasa, the land bordering the Persian Gulf, which has witnessed a far greater transformation of its living conditions in the last 15 years than perhaps any other area of a similar size. The facts are so well known that little

(1) Memorandum in manuscript, written by Dr. Mohamed Mahmoud Al-Sayyad, Professor of Geography at the King Saud University, at the request of the present writer.

need be added here to the statement made above regarding the effect of the oil industry, which indeed was written with the Saudi Arabian oilfields in mind.

We thus see that a combination of various factors has helped to bring about the political unification of a larger part of the Arabian Peninsula than has ever been effected before, and to bring it into close contact with different cultures and civilisations, while a strong movement for the revival of Islamic values has acted as a safeguard against any deleterious effects which the new materialism might produce.

CONCLUSION

The present survey has shown that considerable numbers of nomads still exist in almost all Middle Eastern countries. Some countries have worked out a definite policy for the sedentarisation of nomads; others are relying on the effect of the normal development of their economic resources and social services.

The survey has shown that in addition to nomadism there is an equally important problem of tribalism. Groups with a tribal organisation constitute half or more of the population of Saudi Arabia, Iraq and the Sudan. It seems desirable that the economic integration of tribes through sedentarisation should be followed by their social integration with the rest of the population. But, however desirable such a result may be, it should never be forced but should be left to the more gradual evolution of society and social institutions, through education, in all its different aspects. This process might take several generations, and its pace should be left to circumstances. It is generally felt that the tribal spirit should not be destroyed but allowed to merge gradually into the national spirit, through the usual co-operative activities of the modern State.

APPENDIX

Land Reform in Egypt, Syria and Iraq

The great discrepancy in the distribution of land between large and small proprietors was a common feature of land tenure in Egypt, Syria and Iraq which led these three countries—the last two of them quite recently—to adopt land reform legislation.

A reform was enacted in 1952 in Egypt, where agricultural land is very much more limited than in the other two countries concerned and there is little hope of any early increase. Moreover, the pressure of population in Egypt is very great both in urban communities and in the Nile valley. The Land Reform Law provided that no landowner might possess more than 200 feddans (a feddan is equal to nearly 1 acre) or 300 feddans if he had children. Any property in excess of this limit had to be surrendered at a fixed price in annual instalments.

The Syrian reform, promulgated on 27 September 1958, also had the effect of redistributing property, but includes special features which are absent from the Egyptian law. The Syrian law differentiates between fully developed irrigated land and orchards on the one hand, and lands which rely more particularly on rainfall, on the other.

In Syria a considerable part of the best land is devoted to the cultivation of fruit, particularly apricots and olives, and the best irrigated lands can yield two and even three crops every year. These two types constitute the first category. Ownership of such land is now limited to 80 hectares (roughly equal to the Egyptian limit), with another 40 hectares to be divided among wives and children living at the time the law comes into force, or born within 300 days after its promulgation. For the other category of land, whose water supply is dependent mainly on rainfall —by no means very plentiful in Syria, and confined to the winter months—the maximum holding is limited to 300 hectares (about 750 acres), and a corresponding proportion for wives and children, if any.

It is estimated that the new law should provide some 3.440.000 acres of land for distribution among landless peasants, small landowners, graduates of agricultural colleges and *tribal groups which are involved in one of the schemes for the settlement of nomads*. Lands which serve such a purpose are thus not confined to those that have yet to be reclaimed, but also include those already under cultivation.

Land reform was promulgated in Iraq on 1 October 1958. The Iraqi law follows the Syrian pattern in distinguishing between lands irrigated by rivers and canals, and those that depend mainly on rainfall, which are mostly situated in the north-eastern districts. The limit for the former is 1.000 donums (or about 250 acres)

and for the latter 2.000 donums (about 500 acres). The figures are quite close to the standard set up in the laws relating both to Egypt and Syria. The principle of fair compensation is also recognised, so that there is no confiscation of land but a transfer from large owners to small ones or to landless peasants.

These laws will have an important effect on the problem of the settlement of nomads and semi-nomads. These will no longer have to wait for new agricultural lands to be reclaimed and new irrigation projects to be carried out. There will be available for them, as well as for poor sharecroppers on large estates, several millions of acres of agricultural lands, in Iraq and Syria, which could be utilised to bring about the required social changes in a much shorter time than would have been the case if they had had to wait until fresh lands were reclaimed.

ENVIRONMENT AND HUMAN ECOLOGY IN EGYPT
DURING PREDYNASTIC AND EARLY DYNASTIC TIMES[1]

BY

KARL W. BUTZER

The oldest known agricultural settlements of Africa were situated in northern Egypt, at Merimde and on the shores of Lake Moeris in the Fayum Depression. Radiocarbon datings gave an approximative value of 6500 years before the present for the Fayum 'A' culture, and it may be assumed that agriculture in the Nile Valley began about 5000 B. C. During the seven millenia that have passed since these first primary village farming communities were established, Man has coped with his environment to secure an existence for himself and his kind. The problems he has faced were at all times manifold : technical and biological problems related to methods of cultivation proper, engineering methods to secure irrigation, drainage and a successful economization of the water resources available, and lastly, the shielding of his fields against the encroachment of the desert and then, under pressure of expanding populations, the enlargement of the cultivable land at the cost of the desert.

Just as the fellahin of to-day use one composite term *gebel* to express « desert», whether a desert mountain, a rolling desert plain, or whether simply sand or stone is meant, so also it appears that the ancient Egyptians used the determinative signifying «mountains», which was equivalent to «foreign». Even to this day the fellahin speak of the *gebel* with an undertone of resentment, which is identical to the hostility of their

[1] Part of the contents of this paper were presented as a Faculty Lecture in Geography and Anthropology at the University of Oxford, June 4, 1959.

forebears to the sterility and latent enmity of the desert. In this sense the ancient Egyptians were the first conscious and recorded «men against the desert», to use the modern catchword, one of the first nations to contrast the fecundity of the water and the soil to the barreness of the desert. The philosophical expression of a conscious realization of this duality of life and death, side by side, and mutually interchangeable, are the fertility cults centered about the rites of Isis and Osiris in Egypt or of Inanna and Dumuzi in Mesopotamia. The very persistance of these practices, which cannot be merely regarded as symbolical or commemorative in nature, underlines the constancy of the struggle between man and the desert, even after mastery over the techniques of water control had once been achieved.

This then is the essence of human subsistence in the arid zone, that the natural forces of the positive and of the negative environment are continually subject to transformation. Sand, as water, is seldom still. It is this changing picture of water resources—be it exotic Nile flow, or local rainfall (Hassân Awad 1959)—and the changing face of the desert environment that we wish to sketch here in its main outlines in as far as they have effected the transition from food-collecting to food-producing economies and the first phases of agricultural settlement in the Nile Valley. A part of the material employed has been presented in detail in connection with earlier investigations already (K. W. Butzer 1958*a*, 1959*c*), to which reference may be made. It remains inevitable however, that repetition will occur, but it is hoped that the reader will overlook these in favour of a more digestible and illustrative sketch.

A. THE NATURAL-HISTORICAL BACKGROUND

1. The natural geographical Habitat of the Nile Floodplain

It is widely realized to-day that the germs of the Egyptian civilisation were the product of a fruitful contact between an endemic Final Palaeolithic hunting and fishing folk on the one hand, and new cultural and ethnic groups originating from the area of the Fertile Crescent on the other[1]. These appear to have brought the basic ideas of plant and animal domestication with them. Once primary agricultural communities are admitted, the geographer must cooperate with the prehistorian to answer the question : *where* could these farming villages develop? This poses a second question, *how* did the Nile Valley look before Man converted the natural to a cultural landscape? Did the earliest agriculturalists have to confront a complex of uninviting papyrus swamps, such as in the Sudd area of the Upper Nile? If this were so, civilized Man could only attack the marshes and jungles of the Valley from a base position on the desert edge, gradually draining the land and eking out a precarious existence until technical supremacy over the environment had been achieved. Or could Early Man settle at will in the Valley from the very beginning?

The Nile Valley as a natural Floodplain.

Like so many rivers of the world the Nile moves across its own alluvial floodplain north of Aswan, a sedimentary plain which has been deposited by the river in the course of repeated seasonal flooding. After the rainy season has begun in Ethiopia the river begins to rise and leaves the low water bed it has incised in the plain. The coarser and heavier load is deposited first of all, immediately on the river banks where the current is strongest. In the case of the Nile these coarser sediments are fine or middle-grained sands which are deposited as natural *levees* along the border of the river. However the velocity of the waters rapidly diminishes as the flood spreads out over the plain, so that the transporting ability is equally rapidly reduced.

The relative composition of the suspended matter transported by the Nile is as follows (Simaika 1953) :

30 % fine sand	0.02-0.2 mm in diameter
40 % silt	0.002-0.02 mm
30 % clay	less than 0.002 mm

[1] A similar fusion of autochtonous Egyptian and of Near Eastern elements preceded the second phase of Egyptian civilization, the Islamic culture.

Simaika was able to observe that the fine sands are mainly transported at a height of 80 cm above the river bed, whereas silt and clay are suspended uniformly throughout the waters. This implies that the fine sand is deposited immediately on the banks of the low water bed whereas the finer, suspended aggregate is deposited over the whole plain. In other words deposition becomes less and less from the river banks to the borders of the valley, and the steep levees built up along the river fall off desertwards with a very gentle slope, generally 2 to 3 m on a distance of several kilometers. Such lower situated *basins* form the greater part of the alluvial plain.

After the flood waters have begun to recede, the levees are immediately left high and dry, while the low-lying basins remain inundated for a longer time. Occasionally the lowest sections harbour perennial waters (marshes or lakes = back-swamps). Similarly the groundwater table is quite deep under the levees during low water, whereas it may even lie above the surface in the lowest parts of the basins. This simple picture of a natural flood plain can still be found to-day in African rivers such as the Chari, Logone or Okavango, where no age-old cultural landscape obliterates many of the characteristic features such as in the modern Nile Valley.

Generally speaking the model of river-levee-basin is complicated by river bifurcations or cut-off meanders. Since sedimentation is strongest on the actual river bed and its immediate borders, this bed is built up considerably faster than the basin country. As a result the bed will sooner or later lie higher than the basins and with the next flood the river will break out of its course with resulting bifurcation or shift of bed. In this way the numerous islands, giving even the modern Nile a braided appearance, come into being. But the old levees remain, even if the river bed has changed. The end result is a complicated network of river arms, islands, ox-bow lakes, new or abandoned levees, marshy hollows and seasonally inundated alluvial basins.

In the Delta, water and sediments are able to spread out over an area twice or three times that of the valley proper, as there are no lateral hindrances as in the limestone gorge of the Nile south of Cairo. Furthermore a large part of the load, as well as the waters, are carried out to

sea. As a consequence the river gradient decreases strongly from 1 : 7000 at the apex to 1 : 19,000 in the northern reaches of the delta. The waters are distributed over countless branches and distributories reducing the gradient and current even further, so that the heavier matter is no longer transported. The levees are appreciably lower and smaller, the basins so low that they may at times deteriorate to perennial swamps or larger lakes. The latter are characteristic for the mouth of the delta, going over into brackish lagoons. These lagoons are cut off from the sea by sand and silt bars built up as barriers by the westerly coastal current.

How does this picture compare with the Sudd basin of the Bahr el Ghazal? Firstly the Sudd basin is not characterized by a high and low water regime, as the waters are exclusively from the region of the Central African lakes. As a result the flooded area is perennially inundated, with a corresponding vegetation and morphology. Secondly the Sudd basin is characterized by a great depth and extent of Pleistocene lacustrine deposits. It is irrelevant for our purpose whether this Lake Sudd had an outlet or not. Important is that the present Sudd basin represents a former lake reduced to a vast marsh. This marsh is continuing to fill up with organic and inorganic sediments, and so the well-known floating marsh islands, the papyrus swamps and the like have come to be characteristic. But neither levees nor seasonally flooded basins occur, and this is the decisive distinguishing mark between the natural floodplain of the Nile in Egypt c. 5000 B. C. and the former Lake Sudd basin reduced to the Bahr el Ghazal swamps of to-day. The wholly erroneous analogy of the primeval Nile to the Sudd swamps was unfortunately sanctioned by numerous geographers, and came to be an axiom in the Egyptological literature. The first to point out this serious misconception was Siegfried Passarge, writing in 1940. However his basic study remained inaccessible in Egypt due to the war, and as a result this noted geographer has not received the credit he has deserved.

From the preceding discussion it was obvious that the extent of perennial swamps and lakes in the Valley was small, almost unimportant, even in early settlement times. The greater part of the plain consisted of seasonally flooded basins as to-day. Yet how perfectly absurd is the idea of the alluvium being uninhabitable to-day! And just as inviting or

uninviting as to-day was the picture of the plain some seven millenia ago. The levees were at all times inviting to settlement, being inundated for only very short periods of several days at the peak of the flood. It seems quite likely that the greater part of the modern villages, standing several meters above the plain on their own cultural debris since centuries or millenia, were originally built on active or abandoned river levees. From the very beginning Man could build his abode upon the levees or upon the desert edge, and after the floods had receded, throw his crop seeds upon the wet mud of the basin floors or graze his cattle and other herds upon the lush vegetation of grass, herbs, brush and young shoots. When the water rose again the harvest had been gathered in and the livestock could pasture upon the levees or on the desert margins of the alluvium.

Theoretically these ecological assets would not be so optimal in the delta of the river. However in the case of the Nile providence had provided an equalizing asset : the *turtlebacks*. During the late Upper Pleistocene degradation of the Nile steep channels were incised in the older deposits of fine or coarse fluviatile sands once deposited by the lowermost Nile during periods of high Mediterranean sea-level. The last, Würm-age regression of the Mediterranean appears to have taken place so quickly that the lower Nile had little energy for lateral erosion. As a result large remnants of the older Pleistocene sediments were preserved between the various Nile arms of the Delta. These are to-day known as turtle-backs, which occur at the head and in the central, eastern part of the Delta, particularly extensive being those northwest and again southeast of Benha. One such «sand island» even to-day achieves 13 m above the alluvium. It is noticeable that the recent mud layers are thin on the peripheries, and generally speaking their surface goes over into the alluvium with a very gentle slope. As a result it can be assumed that their present areal extent is very much smaller than it was seven millenia ago. The accumulation of Nile mud and Man's agricultural activities have greatly reduced the turtle-backs in size. This can be most easily appreciated from the air, where it is possible to see a large ring of lighter coloured fields surrounding the turtle-backs. This is due to the admixture of sand and silt due to continuing extension of alluvium and cultivated land.

Even to-day there are countless such sand islands occurring between the Nile branches over an area of almost 5000 square kilometres in approximately the rectangle Cairo-el Quantara-el Simbillawein-Khatatba. This area would have been optimal for human settlement : where the deepest basin lands would normally occur, there were patches of dry desert. Even if the levees were smaller, settlements could be made on the margins of the sand islands. So there was cultivable land and dry land, but little or no marsh zone at all. This is supported by the fact that only one of numerous borings in the central or southern delta, namely at Shinraq, struck lacustrine as opposed to fluviatile deposits. To these assets can be further added that the location behind the Nile arms provided defense against enemies and protected the herds and fields against desert marauders. In review then, the Delta, in particular its southern and eastern parts, was also accessible and inviting to human settlements from the very beginning. The question of alluvium and sea in the northern half of the Delta will be discussed further below.

Some Consideration on the Location of Predynastic Settlement.

A brief survey of the location of the known predynastic settlements in Egypt shows that all known town or village-sites are preserved exclusively on the edge of the desert, so Merimde, Maadi, Badari, Mahasna, Abydos, Nagada, Armant and Hierakonpolis. Cemeteries have been neglected, their very existence at localities without settlement traces however presupposes the existence of villages now buried under the alluvium. The question then is : were all settlements in pre-mid-Gerzean (Nagada II) times located on the desert edge, or must we assume towns and villages in the valley itself?

The Mesolithic sites of Egypt, generally grouped under the microlithic Helwan culture, are limited to Helwan, Omari and Laqeita Wells. Almost equally modest and localized are the finds of the preceding sub-microlithic Epi-Levallois III industry. As far as we can judge from their cultural remains, these folk can be classified as terminal food-gatherers in the sense of Braidwood and Reed (1958). These authors have attempted to give broad estimates of population density for cultures of various

economic character from modern analogies. In this way they offer a suggestion of 5 inhabitants per 100 square kilometers for such specialized collector groups. Even if the estimate is several hundred per cent «off», it does give a qualitative idea of the distribution of population to be expected. The present cultivable land in riveraine Egypt amounts to some 23,500 km². In prehistoric times this area may have been very approximately 16,500 km²—deducting 5000 km² for lakes, lagoons and backswamps in the Delta (see below), 1000 km² for subsequent land reclaimal in the Fayum and 1000 km² for subsequent areal expansion of alluvium in the Valley. Admitting the inhabitants were generally specialized collectors one would get *a total population in the order of 1000 inhabitants for the Nile Valley and Delta about 5000 B. C.* This is pitifully little, but does explain something about the extremely scarce and modest finds of the later pre-Neolithic industries.

Some five centuries later we know of the existence of Merimde and Fayum 'A', and a little later, the first upper Egyptian cultures at Tasa and Badari. The former have been classified as late Neolithic by previous authors, the Badarian is already Chalcolithic, i. e. copper was known and employed. These were primary village-farming communities as regards their economic level, a class for which Braidwood and Reed estimate some 1000 inhabitants per 100 km². One can argue about the extent of primary agricultural villages in Merimdan times, but no one can contest that farming villages were characteristic during the Gerzean period. On this basis we can estimate *a total population in the order of 100,000-200,000 for the second half of the fourth millenium B. C.* Even if we take the lower figure as applicable, a tremendous expansion of the population can be assumed for the 5th and 4th millenia, something characteristic of food-producing as opposed to food-collecting cultures. How then do the settlement traces of Predynastic times compare with this theoretical estimate of total population?

Merimde had an area of about 180,000 m² (map in H. Junker 1932) with cultural debris attaining an average depth of 2 m. This necessitates a dense settlement, of not too short duration. At Maadi over 6000 m² of settlement area had been exposed by 1936, the rubble being 20-100 m thick (Menghin and Amer 1932, 1936). J. Garstang (1903) gives

a map section of 7100 m² for Mahasna, W. Kaiser reassessing this area at 10,000 m². The remains form only a thin veneer however, and it is hazardous to estimate the true size of the former settlement. Hemamieh North Spur (Badari) was only 200 m², with an average sebakh depth of 150-180 cm (Brunton and Caton-Thompson 1928, p. 69). T. E. Peet (1914) gives a value of 700 m² for Gerzean Abydos, the debris attaining 1 m thickness. For Nagada (South Town) this value is 15,000 m² according to the map of Petrie and Quibell (1896), with a depth of 1-60 cm. Kaiser (1959) reassesses this area as 50,000 m² on the basis of a new examination. In 1939 (Mond and Myers) the excavated part of predynastic Armant had amounted to 716 m². Predynastic Hierakonpolis was the largest Upper Egyptian settlement. A new 1 : 15,000 topographic-geologic map has been constructed by the writer and Dr. Kaiser (1959), but it is difficult to give a definite areal figure. Settlement remains, probably of one central town and many subsidiary villages, cover a total area of 1,000,000 m², but in the author's opinion, it is better to employ the areal extent of the more dense debris. This amounts to 50,800 m² after our survey in 1958. These then are the areal estimates of the prehistoric setlements, as far as we can suggest them at the moment.

The matter of actual associated populations is exceedingly difficult, but we may again attempt to give a partial answer. A. Badawy (1954, p. 13-27) has presented a fine study of Predynastic architecture in Egypt. Shelters or huts were sunk into the ground, walls of straw or reeds lining the sides of the hollows. These wattlework constructions were carried up above the ground level and coated with plaster. The oval or circular plan gradually was superceded by a rectangular one, and more durable materials such as wood or stone were later employed. At Hierakonpolis the writer could study these building forms in detail. The pits dug out usually amounted to 1 or more meters deep, with as area averaging 7 to 15 m². Generally the density of such dwellings was little more than 1 hut per 65 m². Interestingly Braidwood and Reed obtain 25 houses for Neolithic Jarmo using a similar argument. They further assume 6 inhabitants per dwelling. This seems logical considering the size and family numbers of rural houses in the Near East to-day.

On this basis of approximation we would obtain a population of some 16,000 for Merimde, of at least 600 for Maadi, 20 for Badari, no more than 1000 for Mahasna, 105 for Abydos, at least 1500 for Nagada, at least 110 for Armant, some 4700 or at most 10,000 for Hierakonpolis.

As a first consideration it is obvious that Merimde was not the first and not the only Neolithic settlement in Lower Egypt. Even if our estimate is too generous, one must assume numerous farming villages in the Delta area some 6000 years ago. A functioning economy is hardly conceivable without them. Yet no single trace of another settlement occurs on the desert flanks of the Delta. This implies these other villages must have been situated in the southern half of the Delta, where they are now buried under many meters of silt. It is curious why Merimde remains the only town of Neolithic date, uniquely situated outside of the Delta. At the same time however Merimde confirms our argument that *village farming communities have flourished in the adjacent parts of the Delta,* between the protecting branches of the river Nile, *since the beginning of food-producing economy in Egypt some 7000 years ago.*

A second consideration, weakened by the two hypothetical arguments upon which it is based, is however at least worthy of mention. Namely that the known Gerzean settlements of Upper Egypt only suppose a contemporary population of at best 20,000 inhabitants. It was shown that settlement was possible upon the alluvium from the start, and it has been mentioned that more cemeteries of Nagada-II age occur on the desert edge, than we know corresponding villages. Yet it is not necessary that Predynastic Man only interred his dead on the desert, yes, there may also have been cemeteries on the plain as well. In other words, even *at the beginning of the Gerzean period no more than half of the population of the Nile Valley lived on the edge of the desert.* In the centuries when Hierakonpolis and Nagada flourished upon the low desert there were already countless villages on the levees and other elevations of the Nile floodplain. Naturally such settlements may have in part been situated on the edge of the desert, only to be buried by alluvium at a later date. This may well have been the case in Middle Egypt (cf. Kaiser and Butzer 1959). But it was not the rule.

The natural Vegetation of the Floodplain.

In order to reconstruct the natural vegetation of the alluvial plain it is prerequisite to know the floral elements of the vegetation associations and the terrain of the countryside. The former can be determined by pollen-analysis, macro-remains from geological deposits, and above all archaeological finds in tombs and from excavations. Pollen-analysis has unfortunately not yet been applied widely in the arid zone, also not in Egypt [1]. However thanks to an unequalled collection of plant and tree remains from Predynastic and earlier Dynastic times, supplemented by tomb reliefs and other works, as well as the testimony of classic authors, the *elements* of the primeval vegetation of the Nile Valley are well known to-day. The systematic study of the former vegetation was successfully inaugurated by that great botanist Georg Schweinfurth in 1884, and thanks to the many-volumed 'Flora of Egypt' (since 1941) by Vivi Laurent-Täckholm in collaboration with Mohammed Drar, we now know more about the Egyptian vegetation in Predynastic and historical times than of any other area not yet investigated by means of pollen-analysis.

The characteristic indigenous trees of Egypt are beyond doubt the Nile acacia (*Acacia arabica* var. *nilotica* Delile) and tamarisk (*Tamarix nilotica, T. articulata*). The first species is still represented by well over 20 varieties in the floodplain and the wadis of the Eastern Desert to-day. The tamarisk is already known from Upper Pleistocene deposits in Wadi Qena and from younger deposits in the valley. The mediterranean species sycomore (*Ficus sycomorus* L.) is probably also an autochtonous form, so also the Egyptian willow (*Salix safsaf* Forsk.). Of further interest in this connection are *Zizyphus spina Christi* Desfont., *Balanites aegyptiaca* Del., *Mimusops schimperi* Hochstett, *Ceratonia siliqua,* etc.

On the other hand it is difficult to estimate the natural status of the immediate forebears of the cultivated palms as *Phoenix dactylifera* L. (date palm), *Hyphaene thebaica* Mart. (dum palm) and *Medemia argun*

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[1] A so-called peat sample from the Delta was submitted to the Palynological Laboratory in Stockholm recently, but was found to contain no pollen (kind communication of G. Erdtmann).

Württemb. Certain is only the fact that the wild date *Phoenix sylvestris* has been found in the Upper Pleistocene deposits of the Kharga Oasis (see Täckholm and Drar II, p. 204 seq.). The well-known « Nagada-plant», represented on Gerzean decorated pottery, has turned out to be the abyssinian banana *Ensete edule* Horan.

The characteristic elements of the marsh vegetation were lotus and papyrus, both of which are no longer native to the Egyptian Nile. The papyrus rush of the ancient Egyptians belongs to the Cyperaceae (*Cyperus papyrus* L.), growing a 3-5 m long stem, limited however to quiet, shallow water (36-62 cm deep) in river inlets, on lake margins or in backswamps. Both the Egyptian lotus *Nymphaea lotus* L. and the blue lotus *Nymphaea coerula* Savig. were represented in ancient Egypt. Further species of note were *Cyperus esculentus* L.; common reed, *Phragmites communis* L.; and stemmy plants like *Juncus acutus* L., *J. arabicus* Adams and sedge, *Arundo donax* L.

However a systematic review of the endemic plants does not give a picture of the natural vegetation. Each element has to be grouped into associations forming individual vegetation types. Without pollen-analysis it is only possible to provide analogies derived from the principles of plant geography and plant ecology. So for example S. Passarge (1940) was able to observe a natural succession of vegetation in little-settled areas near the Delta lagoons. In the lowest basin-hollows reed swamps, on the heavy soil of the basins thorn brush. The latter is seasonally inundated, after which grass and herbs cover the ground. Thirdly bush and brush develop on the natural levees, the soil being hidden under grass and herbaceous plants after occasional flooding. The latter picture could be amplified by Passarge's observations carried out in the Kalahari and Central Africa, where Man has not depleted the vegetation in search of firewood. In these areas there is treegrowth upon the natural levees, made possible by groundwater available throughout the year. And in this sense groves of sycomores thrive upon the elevated locations of human settlement in the Nile floodplain even to-day.

In review then the ancient Egyptian floodplain landscape was dominated by *three vegetation complexes : in the areally limited back-swamps an association of papyrus, lotus, sedge and reeds; in the seasonally inundated alluvial flates*

—forming the greater part of the floodplain—*low scrub with a lush grass and shrub vegetation; on the ridges and hillocks marking ancient and actual levee banks, groves of acacias, tamarisk and sycomore*. The latter served as an area of permanent settlement, growing in height with silt, dust and debris according to the rise of the floodplain, upon which Man and his flocks found refuge during the flood season. The greatest part of the plain formed an ideal land for Man to sow his crops and graze his beasts. The backswamps were very limited in size and did not hamper cultivation until population pressure forced their drainage. Before this these marshes formed a reservoir of game. The process of swamp reclaimal was not, as is widely supposed, the major activity of Man in Predynastic and Old Kingdom times. The persistance of fishing parties, fowling excursions and spear hunts in the back-swamps of the Nile floodplain until the close of the New Kingdom documents their existence into late Ramessid times. Until the 20. Dyn. there are few inscriptions referring to swamp drainage which compares strikingly with innumerable references to irrigation in its various forms.

Recently H. Larsen (1957) has suggested that the existence of the *Ensete edule*, apparently in great number, presupposes a dominantly swamp or jungle-like character of the Nile vegetation in Gerzean times. He bases himself further upon the supposed 20 m aggradation phase at Maadi. We have already indicated elsewhere (Butzer 1958*b*, p. 67; 1959*c*, p. 26-27) that the silts struck by the Maadi and Turah bores and trenches were not Nilotic but Middle Palaeolithic. The heavy mineral statistics do not show an appreciable difference from those of the Sebilian silts. With relative frequencies of some 24 % iron ores, 37 % amphiboles 24 % pyroxenes, 9 % epidotes etc. it seems of value to draw attention to Shukri's (1952) samples from Aswan or Kom Ombo. The so-called final Palaeolithic implements reported but unpublished from the base of one silt section need to be typologically analyzed, and even then, one must count with the possibility that this mud was seasonally viscous at one time or other—a feature known to have occasioned Neolithic pottery sherds into indisputably secondary positions elsewhere in Egypt. The reason for our doubts in this matter are simple. In the course of extensive and intensive geological examinations on the low desert on

both banks of the Nile we were unable to find a trace of Nilotic silt primarily deposited above the present level of the alluvium. Only in the Nile-Fayum and Merimde areas could, apart from the Sebilian silts of southern Egypt, the well-known Upper Pleistocene silts in 5-8 m or more be observed. Under these circumstances it does not seem feasible that a Holocene aggradation phase to almost + 20 m should leave no traces other than in the Maadi-Turah area. The latter sections are surely deserving of a closer investigation. The botanical aspects building themselves up around this concept are of course wholly hypothetical, as the *Ensete* could thrive at will in the backswamps and possibly also on the alluvial flats. Certainly its frequency as pottery motive is due to its economic rather than to its numerical importance. The tree stumps of the low desert in Upper Egypt will be referred to further below. Summarizing we do not see any convincing reasons for assuming a + 20 m Nile aggradation in Neolithic times, although it is not improbable that the flood levels were relatively (but not absolutely) higher than to-day. This is supported by the evidence from Mesolithic Khartum where A. J. Arkell (1949, p. 109-110) has given good reasons for a Blue Nile flood level exceeding that of the present by 4 m. But we are unable to follow his argument in a later publication (1953, p. 8), in which this figure is raised to 10 m. *Higher floods would not change the picture of the floodplain* however. The stronger the floods, the greater the load, and the faster the deposition. The levees would grow correspondingly quicker and higher, adapting themselves in a new hydrological equilibrium.

Alluviation as a Function of variable Nile Flood Volume and Mediterranean Sea-Level.

During the later Gerzean period the last settlements on the desert edge were abandoned in favour of townsites on the alluvium. So for example Mahasna and Armant break off quite suddenly in late Gerzean times, while Hierakonpolis was shifted to a site 500 m further east, within the cultivated land. Since the historical unification of Upper and Lower Egypt agricultural settlements have been confined to the alluvial plain. It is therefore of interest to investigate the extent of Nile

mud deposition at the onset of local agricultural and the rate of sedimentation in succeeding millenia. This is a matter of vertical and of horizontal alluviation.

The present mean depth of the alluvial fill of Nilotic silt has been estimated at 11.2 m for the northern Delta, 8.5 m for the southern Delta, 9.7 m for the stretch Cairo-Minya, 8.5 m Minya-Qena, and 6.7 m Qena-Aswan (J. Ball 1939, p. 163). This modern mud overlies an earlier Holocene filling of sand, silt and fine gravel which apparently aggraded to level out the deep valley eroded by the Nile in Epi-Levallois III times (Butzer 1959*b*, 1959*c*). This lower Nilotic bed attains a depth of 2-5 m at el Matana, 3-7 m at Luxor, 12 m at Qena, 6 m at Balyana, 2.5 m at Tahta and 10.5 m at Asyut (see Sandford 1934, p. 103-104; Fig. 25). Whether this coarser Nile load represents an influx of local wadi material in Holocene times or whether it merely consists of older Nile deposits subjected to lateral erosion after the transition from vertical incision to aggradation, is not easy to say. At any rate the matter would be well worth investigating.

Just precisely when accumulation changed over from coarser to finer materials, and the typical silt-mud deposition began, can only be guessed at until better means of dating are available. Theoretically one could reason—if the subrecent annual deposition of 1.03 mm of mud could be extrapolated—that silt accumulation began about 7600 B. C. in the northern and 4600 B. C. in the southern part of the valley. This would be logical as a gradual response to a rising Mediterranean sea-level in Postglacial times, first noticeable in the Delta and then progressing slowly upstream. This is a bold but illustrative approach. In point of fact however, the rate of mud sedimentation will hardly have been uniform. For, it would be presumptious to assume that neither the Blue Nile flood volume nor the Mediterranean sea-level (as base level of erosion) had fluctuated in the course of the last seven millenia.

The archaeological literature on the topic of this rate of sedimentation is of a summary and next to useless character, so for example the figure of 10 cm mud accumulation per century quoted by Sir Flinders Petrie. In another publication (Butzer 1959*c*, p. 24-27) we have discussed this subject in detail and it does seem probable that 1) *60 % of the*

Nilotic mud had been deposited before the 1. Dyn. (*c. 2850 B. C.*), 2) *mud deposition was quite limited between about 1960 and 900 B. C.* and, 3) *some 20-25 % of the Nilotic silts have been deposited since about 500 B. C.* These empirical figures can be theoretically explained in terms of the two natural factors governing deposition : flood load and sea-level. From Mesolithic Khartum (Arkell 1949, p. 109-110) it is known that the Blue Nile flood volume was considerably greater c. 4000 B. C., probably a result of greater moisture in Ethiopia at this time as well. This would certainly effect the Egyptian Nile. Then in Old Kingdom times there are historical documents that the flood level let off steadily (unpublished study by H. W. Helck), whereas repeated famines due to weak floods are repeatedly reported from the years c. 2100-1900 B.C. (cf. evidence in Butzer 1959*c*, p. 67-69). In New Kingdom and late Dynastic times records of exceptionally high floods become frequent, and the testimony of Herodotus (450 B. C.) and of Roman authors in the 1. century shows that «strong floods» achieved 9.54 m as a rule, which is 50-100 cm higher than was the case in Islamic times. The historical evidence of long-term trends of Nile volume seems to fit in with the picture of actual deposition.

The problem of Mediterranean sea-levels in Postglacial time has been treated by the writer (1958*b*, p. 38-39) and D. Hafemann (1959). The salient features are a low stand at -100 m during the maximum of the Würm regression (c. 20,000 B. C.) ; a rise of over 50 m between 9000 and 4000 B. C. ; a stand at + 4 m, lasting several centuries, c. 3500 B. C. ; a drop to a longer halt at + 2 m, c. 2000-1000 B. C. ; a drop to well below sea-level attaining at least -2.5 m 400 B. C., rising to -2.0 m in the 1. century A. D. and regaining its present value in early Islamic time. Over fifty years ago attention was drawn to the effect that the Delta towns and particularly Abuqir are 2.6 m lower, relative to the sea, than they were in classical times. From this a subsidence of 2-3 m was deduced for the Maryut and the Delta, attributed to a compaction of the looser Delta sediments. In view of the unequivocal evidence from all over the Mediterranean, Hafemann (1959) concludes that there was a true eustatic rise in sea-level amounting to 2.5 m between 500 B. C. and 500 A. D. This puts a question mark beside the Holocene Delta-

subsidence theory. The matter can be amplified by a study of the profiles of the younger (Abusir and Gebel Maryut) offshore bars extending from Alamein to the Maryut (Butzer 1959*d*). These Upper and Middle Pleistocene barrier bars do not show any distinct sag towards the north-east, as should be evident if subsidence had occurred in the Maryut. Instead there is a sharp discontinuity in level at the longitude of Mex, after which the Abusir bar jumps abruptly back to a higher level and continues undisturbed to the site of ancient Canopus. This can, in view of the absence of any visible faults, not be attributed to graben-faulting or the like, but would appear to have an exogenic origin. The present elevation of the Delta cities would then seem to be an eustatic and not a tectonic feature.

Rising sea-levels before 3000 and again after 500 B. C. would favour aggradation in the Nile Valley, whereas the regressive tendency between 3000 and 500 would have a reverse effect. This once again fits in with the empirical evidence.

How then does this matter of sea-level fluctuations effect the ancient topography of the Delta coastline? Since the Nilotic mud of the northern Delta averages only 11 m, none of the present land surface will have been submerged before the Mediterranean had risen to at least -11 mm. s. l. According to radiocarbon dates of the Postglacial eustatic rise in ocean level, the Mediterranean can be estimated to have achieved this level 5500 B. C. But we saw that mud deposition should have began before 7600 B. C. in the far north, and that, accepting a uniform rate of deposition, 2 m of silt would have been laid down by 5500, i. e. deposition and rising sea-level could to a large measure be expected to balance each other off for at least another millenium. At any rate the popular concept of a Nile Delta deposited and pushed seaward only in Holocene times after a period of Late Glacial—Early Holocene immersion does not appear applicable. The Delta existed in at last its present dimensions since at least the last interglacial period, only to loose ground in Post-glacial times until after the maximum sea-level at + 4 m had been abandoned.

Only after sea-level rose to above that of the present were the Nile waters dammed back behind the lagoons. Only then was a larger part

of the northern Delta submerged. The extent of marine or brack-water inundation can be acertained from a study of the existing boreprofiles from the Delta. From profiles given by Fourtau (1915) and others in the Geological Museum, Cairo, we can list following details :

Kafr el Dawar.......	7.5 m	silt and sandy clay on brackish clay.
Rosetta............	10.5 m	silt on 19 m brackish clay, overlying marine sand.
Baltim............	1 m	silt overlying 3.7 m marine sand.
Khasha	6.4 m	silt and clay upon 0.8 m brackish clay.
Masraf Omum......	4.5 m	silt overlying 5 m brackish clay intercalated with 0.5 m coarse sand.
Basandila	1 m	silt overlying 4 m brackish clay.
Damietta..........	11 m	silt and clay overlying 7 m brackish clay.
Manzala	14.8 m	silt and clay over 5 m brackish clay intercalated by 1 m clay, overlying 1 m marine sand.
Matariya	20 m	silt over 1.5 m brackish clay, overlying marine sand.
Port Said	6 m	brackish clay (recent) over 6.1 m clayey sand and clay, overlying 6 m marine sand.

These are the only profiles known to us recording marine or lagoonal conditions of deposition. The brackish clay is obviously a lagoonal deposit of the type forming in the brackish Delta lakes of to-day. These profiles then delimit the extent of the maximal Flandrian Transgression c. 3500 or 4000 B. C. Contrary to our above supposition, it is interesting to note that none of the brackish clays or marine sands overlie typical Nilotic silt! Where tapped the basal sediments consist of clayey sand, sandy clay, clay or coarse sand. Except for the latter Pleistocene material, the base complex is similar to the early Holocene filling of the buried Epi-Levallois III channel of the Nile. This may provide a clue that *the actual silt phase of the Holocene Nile did not begin before* 4/5,000 B. C.

Employing the limit of the above profiles to those without traces of marine or brackwater sedimentation, and extrapolating on the basis

of the contours it is possible to give an approximation of the coastline and the extent of brackwater lagoons for the time of maximal Holocene transgression (Fig. 1). Interestingly no marine sediments occur in the Maryut whereas only one of five bores reached brackwater sediments.

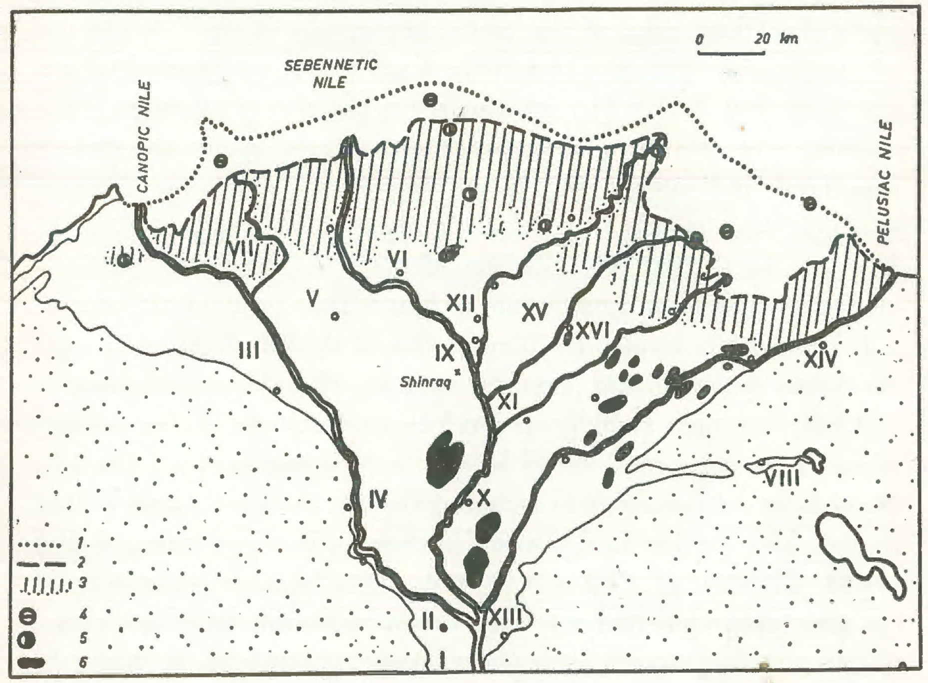

Fig. 1.—*The Delta in Predynastic and early historical Times.* 1 = moderncoastline, 2 = coastline c. 4000-3000 B. C., 3 = extent of brackish lagoons c. 4000-3000 B. C., 4 = borings with Nilotic mud over brackish clay and marine sands, 5 = borings with Nilotic mud upon brackish clay, 6 = turtle-backs. Desert dotted. River courses and names after description of Herodotus (modified after J. Ball 1942), older Delta cities indicated by open circles (generally after J. A. Wilson 1955). Lower Egyptian nomes in 1900 B. C. located by Roman numerals : I. Memphis, II. Letopolis, III. Kom el Hisn, IV. Terenuthis, V. Sais, VI. Xois, VII. Metelis, VIII. Pithom (Tjeku), IX. Busiris, X. Athribis, XI. Leontopolis, XII. Sebennytos, XIII. Heliopolis, XIV. Sile (Tjaru), XV. Hermopolis (NW Mendes), XVI. Mendes. These names are identical with the leading cities (already indicated with exception of Metelis and Hermopolis).

This must imply that a Nile arm, possibly the Canobic of Herodotus, embouched immediately east of the peninsula of Abuqir, thus preventing marine flooding. It is interesting that *even with a Mediterranean level at*

+ 4 m the open sea only covered about the area of the present Delta lakes Edku, Burullus and Manzala, without the adjoining marsh zone. Lagoonal conditions were definitely limited to the south by the present 3 m contour. Employment of further bores would inevitably add more detail to Fig. 1, but it is unlikely that the overall picture might change much. If then we compare our present knowledge of the coastal topography of the Nile Delta in late prehistoric times with that of the Tigris-Euphrates, it is significant that Lees and Falcon (1951) also reject the theory of recent delta-building and extension. However these authors ignore the eustatic hypothesis and attempt to explain everything by tectonic agencies, although there is only very indirect evidence of this at their disposal. Bore profiles through the alluvium of the area immediately upstream of Basra would be of great value in future assessment of the matter.

It is dificult to employ the bore profiles of the Nile Delta to estimate the former extent of the perennial swamps. It is significant however that only one bore at Shinraq struck lacustrine shells of *Limnaea* and *Planorbis,* as opposed to fluviatile species (Fourtau 1915). The map Fig. 1 has been completed by including the Nile topography as described by Herodotus (c. 450 B. C.), modified after the interpretation of J. Ball (1942, p. 24-28). This will at least give a better approximation of the true topography in Predynastic times. Although Herodotus claims the present Rosetta and Damietta mouths were artificial, it should be pointed out that a bore at Shiribin on the Damietta arm, situated at 3 mm. s. l., struck 10 m silt over 20 m sandy fluviatile deposits! These thick river sediments rest on coarse Pleistocene sands.

Fig. 1 also includes the location of the 16 Lower Egyptian nomes at the time of Sesostris I (1971-1930 B. C.). It is amusing that all are situated on « dry » ground, excepting Metelis (VII). This nome is however strikingly called the Harpoon Nome. Finally the location of the Delta cities, whose existence is documented before Late Dynastic times (after J. A. Wilson 1955), has been indicated. As Wilson points out, almost all of these lie above the present 6 m contour. The exceptions have, in part, carried epiphets such as « swamp-island » or « sand-island » (H. Kees 1954, p. 11, 108-109), which suggests these were situated on levee banks (Buto, Behdet) or turtle-backs (Imet, Tanis).

Bearing in mind that the recent Mediterranean regression achieved its lowest point c. 500 B. C., it is possible to interpret the colonisation of the northern Delta in Late Dynastic and Ptolemaic times *physically* as a response to natural marsh drainage and northward extension of the land surface. According to Makhzumi the present Delta lakes were only created in 961 A. D. (Shafei 1952) by marine transgression, probably in the course of the rise in sea-level since the 2nd century A. D.

2. Geological Deposits, Fauna and Vegetation of the Desert Zone during the Neolithic Subpluvial.

Geological Indications of Precipitation during Neolithic and Chalcolithic Times.

The existence of post-Pleistocene moist spells in arid regions is gradually becoming commonplace knowledge, although such climatic fluctuations can, of course, not be compared with the Pluvial phases of the Pleistocene. Geologically not of great importance, their ecological significance cannot be too greatly stressed however. What then is the geological evidence from Egypt speaking for greater precipitation in Neolithic times? Admittedly this evidence is minute and detailed, and of a specialized character. But it is nevertheless there and deserving of a comprehensive review.

The excavations at Merimde (Junker 1940) exposed a thin but fairly continuous gravel horizon above the first Neolithic settlement layers. These pebbles were apparently of appreciable size and suggest a period of sheetflooding after appreciable rainfall. On an experimental basis G. Knetsch (1954) has observed that present day spates on the low desert at Giza attain little energy for transport of all but fine sand. In the absence of any wadi (there are only small rills in the desert surface) at Merimde, widespread gravel transport in Neolithic times does *mean* something. At Maadi Amer and Huzayyin (1952) were able to indicate deposition of coarse gravel and sand at the mouth of Wadi Digla in early and post-Gerzean times. Rushdi Said (1953) has investigated recent transport and incision in this wadi, showing that vertical erosion is

characteristic to-day. Again two bores near Helwan (cf. Fourtau 1915) indicate considerable wadi activity, namely a 6 m bed of sand and gravel contemporary with the basal alluvium.

Passing out of the zone of present-day rainfall to the Fayum (long-year mean less than 10 mm), Sandford and Arkell (1929, p. 60-61) described a section at Ezbet George with 1 m of fluviatile rubble containing Predynastic flints, overlying mud of the 18 m pre-Neolithic Fayum lake. These sediments were deposited in a now nonexistent surface drainage channel. An interesting sequence can be gleaned from the publications of Brunton and Caton-Thompson (1928, p. 73-76) from Badari :

a) 60 cm Gerzean cultural debris.
b) Up to 27 cm clean, unconsolidated scree.
c) 30 cm Amratian-Gerzean hearth deposit.
d) 15 cm Amratian deposit.
e) 15 cm Badarian cultural deposit.
f) Up to 30 cm limestone scree cemented to a resistant breccia, probably during the period of Badarian settlement.
g) Limestone debris with Badarian pottery sherds.

From the unconsolidated character of layer *b*) it can be deduced that maximum moisture occurred before 3500 B. C., and was apparently concentrated c. 4000 B. C., as the formation of such a breccia (see Pl. 1) requires appreciable atmospheric moisture (present annual mean 4 mm !). The last archaeological site with palaeoclimatic implications is Armant (Mond and Myers 1937, p. 7-8), where S. A. Huzayyin recognized a 1.6 m thick, finegrained wadi deposit under 12 Dyn. graves and upon Badarian pottery. This material was laid down by a now-disappeared streamlet over a long period, as a large tree was able to grow during the process of alluviation.

To-day only the larger and intermediate wadis of the Eastern Desert south of about the latitude of Helwan, are able to transport rubble, gravel and sand over longer distances. Such deposits are easy to recognize due to their poor sortment of finer and coarser material, and their irregular stratification. Generally speaking modern spates act erosively

and lead to vertical incision, with transport limited to sand in the immediate drainage channel. The latter applies to almost all wadis of the Western Desert south of about Meidum, and to the smaller wadis of the east bank, not possessing larger catchment areas or appreciable gradient momentum. It seems safe to say that the above features—definitely dated archaeologically—verify the existence of a subpluvial phase somewhere between 5000 and 2350 B. C. It also helps to date a part of the wadi activity of uncertain age which has eroded and redeposited the Upper Pleistocene deposits in Middle Egypt. Here the small east bank wadis have generally removed all traces of Würm pluvial terraces, building up large fans on the low desert (Map 1, *Qw* in Butzer 1959*a*). Obviously a good part of this work will however still belong to the Pleistocene, in particular the Epi-Levallois II moist interval. Similarly the finely stratified local deposit of clayey sands and fine limestone debris between Matahra el Sharqiya and Beni Hassan may still have enjoyed some sedimentation as late as early Holocene time (Butzer 1959*a*, 1959*c*). Being quite unconsolidated it cannot be of Lower Pleistocene or even Pliocene age, otherwise erosion would long have removed it at this highly exposed locality. We believe it to be a large fan deposited by numerous smaller wadis in sheetfloods—although this is no more than a hypothesis. There are only hellenistic and islamic remains on the surface, which leaves the possibility open that some deposition persisted to a later date.

Of interest to this topic is lastly the evidence in favour of a period of warm climate, the Postglacial thermal maximum. F. W. Braestrup (1947) has called attention to such tropical relicts as the water plant *Pistia stratiotes*, Degen's toad *Bufo vittatus*, the fish *Gymnarchus niloticus*, the Basilisk chamaeleon, several tropical snakes and mollusca in the Delta or in the Fayum. Braestrup believes these tropical forms are relicts of a warmer period, only able to survive in their more favourable micro-habitat. In this connection it would be relevant to mention the weak layer of rubefaction (5 cm) evident on the 1.5 m (Epi-Levallois II?) terrace of a wadi immediately south of Deir Tasa (Butzer 1959*a*). This zone of red weathering indicates a short and moderate interval of warm, moist climate following the last Upper Pleistocene development of a

brown soil, under cool-moist conditions. One could implicitly infer a Neolithic date for this. However the 1.5 m terraces in Upper Egypt do not seem to have been effected, possibly the subpluvial was appreciably weaker so far south. In retrospect then, the geological evidence of greater moisture during the chronological equivalent of the Atlantic phase is no longer a matter of individual idiosyncrasy as far as Egypt is concerned.

From the southern Sahara there is also considerable evidence of similar tenor : there are indications of greater water action in the Libyan Desert wadis during Neolithic times ; on the Sudan margins of the Sahara there are numerous clay deposits of former rainwater pools as well as freshwater mollusca where no life exists to-day (Sandford 1936) ; in the Khor Abu Anga, emptying into the Nile below Khartum, a red-brown sandy clay with the large land snail *Limicolaria flammata* was deposited in 'mesolithic' times (A. J. Arkell 1949*b*, p. 7) ; several faunal and floral elements from Mesolithic Khartum, not responsive to a riveraine environment, require a considerably higher precipitation (Arkell 1949*a*, p. 109-110) ; at Shaheinab nearby the occupational material of the site seems to be distributed throughout a gravel bed of the Wadi Shush (Arkell 1953, p. 7). The evidence from the Western Sahara is also manifold.

The close of the Neolithic subpluvial was also recorded by geological deposits in Egypt. It appears that aeolian activity took on an important character, such as had already been the case before 5000 B. C. (1959*b*), in later Old Kingdom times. Sand dunes invaded the Nile Valley in western Middle Egypt, probably covering a 175 km stretch of former alluvium to a depth of 0.5 to 3.5 km by many meters of sand (see Fig. 2, Pl. 4). It is probable that this invasion was facilitated by weaker Nile sedimentation and an eastward retreat of the Bahr Jusef (Butzer 1959*b*, 1959*c*, p. 69-71). A precise date for the onset of this aeolian deposition upon Nilotic silts cannot be obtained from the profiles in question at Tuna el Gebel or Dalga.

However there are indirect indications elsewhere. So at Hierakonpolis in Upper Egypt where a Predynastic cemetery in the Sebilian silts was denuded by later wind action, which removed up to 2 m of fairly resistant

silt, exposing the burials. This material was laid down, together with sand, upon a part of the Gerzean settlement in the lee of the cemetery (Pl. 3) (Butzer 1959*b*, Kaiser and Butzer 1959). Again there are interesting features at the site of the German-Swiss excavations of the

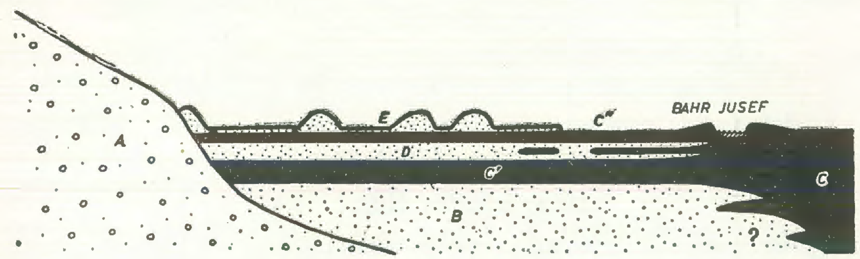

Fig. 2.—*Conventionalized Section of the Marginal Valley Dunes between Tuna el Gebel and Dalga.* A = Pleistocene gravels, B = Older Dunes, c. 2350-500 B. C., C = Nilotic silt, C′ of Graeco-Roman age, C″ of Islamic age ; D = Lower Younger Dunes of Byzantine to Islamic age, locally intercalated by silt, E = Upper Younger Dunes (subrecent).

sun temple of Userkaf at Abusir (c. 2480 B. C.). Dr. Kaiser and Dr. Haeny have informed the writer that the walled street joining the valley temple and the actual Re temple high up on the desert was apparently subject to sand accumulation already shortly after completion. To prevent this or to facilitate removal of the sand from a smaller crossection, a dividing wall was built in the Talweg, which was thereby reduced to less than half its original width. Even thereafter the sand seems to have gained the upper hand fairly quickly, or the construction could not have withstood the vicissitudes of time so well. Similarly the base of the Re temple was fortunately already hidden from the view of Ramessid masons by aeolian depoits. It may well be that the admonitions of Ipuwer (9. Dyn. 7, c. 2100 B. C.) refer to the drastic effects of the invading sands—and receding floods— when he says « Upper Egypt has become a desert» (II, 11).

The autochtonous mammalian Fauna of Egypt during the Predynastic Period.

In a previous publication the author (Butzer 1959*c*, p. 36-43) has tried to present a picture of the larger mammalian fauna of Egypt in

Neolithic times. For this purpose a survey of the osteological material and the Predynastic and early historic representations—pottery decorations, stone palettes, ivory carvings, drawing of various sorts and tomb reliefs—were employed. The systematic zoological picture can be formulated as follows :

A. *Ungulatae* :

1. *Artiodactyla ruminantia.*

Camelidae.	*Camelus dromedarius* L.
Cervidae.	*Dama schaeferi* Hilz.
Giraffidae.	*Giraffa camelopardalis* L.
Bovidae.	
Hippotraginnae.	*Oryx algazel* Pall.
	Addax nasomaculatus Blainv.
Bubalinae.	*Bubalis buselaphus* Pall.
Antilopinae.	*Gazella dorcas* L.
	Gazella dorcas isabella Gray.
	Gazella leptoceros loderi Thos.
	Lithocranius walleri Thos.
Ammotragus.	*Ammotragus lervia* Pall.
Capra.	*Capra ibex nubiana* F. Cuv.
Bovinae.	*Bos primigenius* L.
	Bubalus lelwel.
	Bubalus aff. *caffer* Sparmann.

2. *Proboscidia.*

Elephantidae.	*Loxodonta africana* Blbch.

3. *Perissodactyla.*

Equidae.	*Equus asinus africanus* Fitz.
Rhinocerotidae.	*Diceros bicornis* L.
	Ceratotherium simum Barch.

4. *Artiodactyla nonruminantia.*

Hippopotamidae.	*Hippopotamus amphibius* L.
Suidae.	*Sus scrofa* L.

B. *Carnivora* :

1. *Herpestoidea.*	*Felis leo* L.
	Felis pardus Schreb.
	Hyaena striata Zimm.
	Hyaena crocuta Zimm.
2. *Arcotoidea.*	*Canis aureus* L.
	Canis lupaster L.
	Canis vulpes L.

The rodents and smaller felines have been omitted, as their record is incomplete and their importance subordinate. Similarly we have not attempted to treat the domesticated animals, which have been adequately studied by J. Boessneck (1953).

It is apparent that this list refers in the main to the Nile Valley, where the evidence is manifold and varied. In the desert areas we are largely reduced to the matter of the rock-drawings. Summarizing from Butzer (1958*a*) we can regionally sum up as follows, listing the animals in order of numerical importance :

Eastern Desert. Wadi Matuli basin. Wadi el Atwain : Elephant, ibex, ostrich, giraffe, crocodile, gazelle, hippo, antilope; Wadi Rod Ayad; elephant, ibex, gazelle, giraffe, barbary sheep, ostrich and antilope; Wadis Zeidun and Manih : ostrich, ibex, elephant, giraffe, crocodile, antilope, hippo, lion, barbary sheep and gazelle.

These sites are situated 45 to 80 km away from the valley margins.

Wadi Kharit basin. Giraffe, ostrich, antilope, ibex, gazelle, elephant, rhinoceros.

Western Desert. Dakhla—Kharga. Giraffe, antilope, ostrich, ibex, gazelle, elephant and crocodile.

Gebel Uweinat. Ostrich, giraffe, oryx, addax, barbary sheep, ibex, gazelle and possibly fallow deer.

Gilf Kebir. Giraffe, ostrich, oryx, bubal and gazelle.

The question is, how far do these drawings give a true picture of the actual fauna at each locality. For both the Uweinat—Gilf Kebir and the Dakhla—Kharga groups it can be said with some certainty that we are

dealing with autochtonous ethnic groups localized in each of these biozones. In each case the style is too individualistic and characteristic as that we are confronting rock-drawings and paintings of « itinerant artists ». Similarly, for the oldest drawings of the Eastern Desert we can say that at least the « Earliest Hunters » of Hans Winkler (1938-1939) were strictly a desert folk, with no immediate access to the valley. To these belong the great majority of the elements of a savanna-type fauna : elephant, rhino, giraffe, and ostrich. On the other hand the boats, hippos and crocodiles are stylistically beyond doubt the work of Gerzean artists, who appear to have developed trade routes through the Wadi Hammamat. These « aquatic » factors are then no complication. They are the work of Nile dwellers, drawing scenes from the valley. As regards the other, numerous classic objections to the representative character of the rock-drawings, the reader is referred to Butzer (1958*a*, p. 35-36). In our opinion there is little reason to doubt their palaeozoological implications.

The existence of elephants and rhinoceros in the Eastern Dessert has led us to postulate a former rainfall of 100-150 mm in the more elevated Red Sea Hills, compared with 10 mm to-day (cf. Butzer 1958*a*). Similarly the existence of the giraffe in the Uweinat—Gilf Kebir may point to a former rainfall of some 50 mm for these hills, reflecting topography and relief (to-day some 20 mm). The elephants and giraffes from the oases may have had to thank their existence to the then-functioning mound-springs, so that it is better not to deduce anything on that count. As the writer has discussed with G. W. Murray, it may well be that the highlands of the present desert axis enjoyed the overlap of the summer and winter rainfall belts in Neolithic times. As Mr. Murray has expressed it, « This optimum zone would change abruptly and tragically to one of least rainfall so soon as the winter and summer rainfalls retreated northward and southward respectively. » This might help to explain the occurrence of elephant in the Red Sea Hills or Tibesti. The elephant needs abundant water and green fodder (to the equivalent of several hundred liters of water daily) throughout the year. In all evaluations of such evidence however, it is imperative to remember the paramount effect of topography and relief in a hyperarid area (K. S. Sandford).

Just as the actual geological evidence of greater rainfall points to several humps and sags in the precipitation curve, so does the fauna indicate a strong dry spell preceding the main Gerzean culture c. 3600 B. C. At this time elephant and giraffe were seriously decimated in both the Eastern Desert and in the valley. We have designated this as the *first faunal break* due to deteriorating climatic-ecologic conditions. The *second faunal break* can be localized between the 1. and 4. Dyn., i. e. c. 2850-2600 B .C. (Butzer 1958*a*, 1959*c*). During this period the elephant and giraffe, certainly also the rhinoceros, as well as the gerenuk gazelle, *Lithocranius walleri,* were locally extincted. The lion and the barbary sheep were severely decimated. This means that *the specific savanna fauna of Egypt had died out before the Pyramid Age*—due to a declining and fluctuating rainfall in the course of the gradual termination of the Neolithic subpluvial. The 4. and 5. Dyn. enjoyed the last rains of this moist interval as it seems, for a new trend is noticeable among the fauna between the close of the 4. and the beginning of the 12. Dyn. (c. 2480-1991 B. C.). During this time the desert gazelles replace the larger antilopes and the ibex as dominant element of the Egyptian fauna. The addax even seems to have become locally extincted in the Valley and in the Eastern Desert. So also the fallow deer *Dama schaeferi* Hilz. To illustrate this trend, as established from the analysis of 990 representations (omitting hippopotamus and smaller felines and rodents), Fig. 3 provides an approximate graph of the relative composition of the autochtonous mammalian fauna at various epochs. The 'second faunal break' is particularly striking, and a last transformation, characterized by final achievement of internal equilibrium, was closed off by the 12. Dyn. The following table illustrates the matter more precisely.

Each desert hunt scene of the classic 5. Dyn. tomb reliefs shows animals at large on the surface of the desert (Pl. 2). For the first time however the tomb of Mereruka (6. Dyn.) shows a hunt within a fenced enclosure. The terrain indicates desert country but the game was obviously kept and hunted in artificial reserves, which were replenished after the king or his courtiers had enjoyed the traditional sport. This fact is decisive in assessing the zoological implication of the odd thousand animal representations preserved on Predynastic art objects and Dynastic

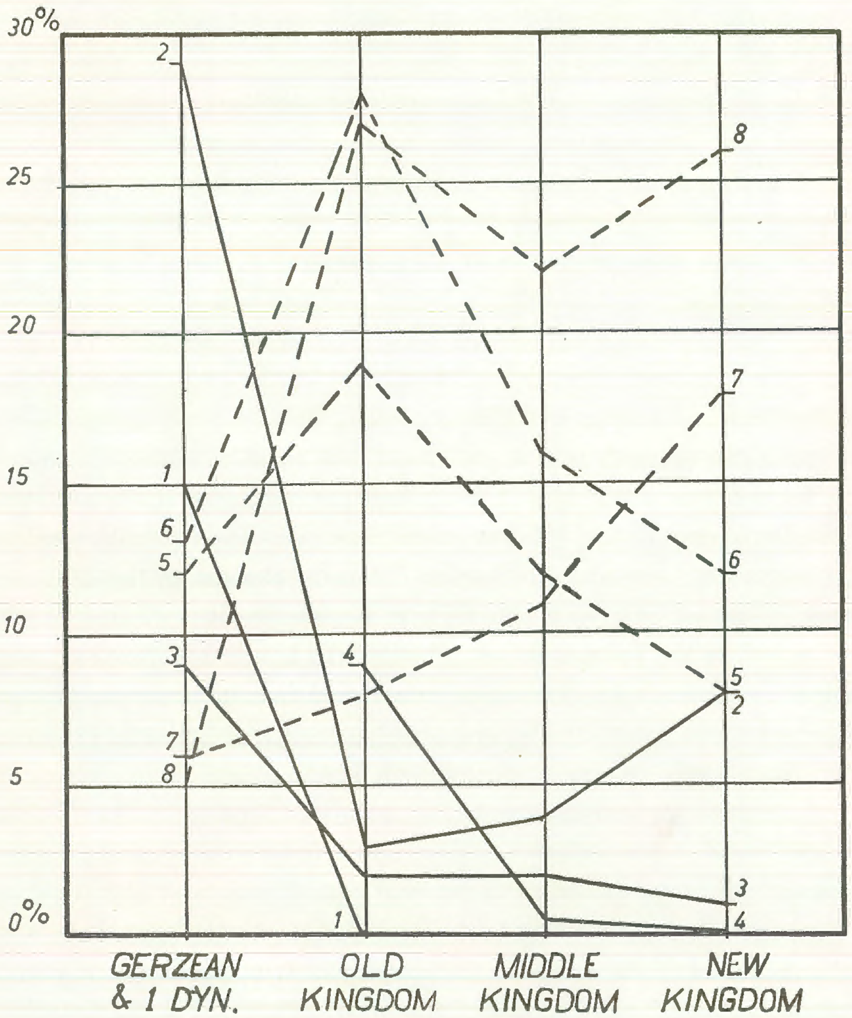

FIG. 3.—*Relative Composition of Animal Representations (in %) : the faunal Transformations of Egypt in Dynastic Times.* 1 = Rhinoceros, elephant and Giraffe, 2 = Felidae, 3 = Ammotragus, 4 = Addax, 5 = Ibex, 6 = Oryx, 7 = Bubalidae, 8 = Gazellae.

TABLE 1.—Animal Representations from the Nile Valley according to Dynasties (3500-1100 B. C.) after Butzer (1959*c*, p. 64)

	Total	Rhinoceros	Elephant	Giraffe	Felidae	Cervidae	Ammotragus	Addax	Ibex	Oryx	Bubal	Gazellae	Struthio	Others (1)
Gerzean/1.Dyn.	281	2	24	16	81	7	25	x (2)	32	35	17	14	2	26
4.Dyn........	53	—	—	—	1	2	—	5	13	12	5	10	—	5
5.Dyn........	199	—	—	—	6	5	3	14	35	50	18	52	1	15
6.Dyn........	128	—	—	—	2	1	3	14	20	40	4	34	1	8
11.Dyn........	72	—	—	—	2	3	2	1?	14	18	5	24	—	3
12.Dyn........	103	—	—	1?	6	9	2	—	14	18	20	25	2	7
18./20.Dyn....	154	—	—	—	12	5	2	—	12	17	27	28	13	20

reliefs and paintings. An explanation can be found from analysis of the New Kingdom drawings, where the proportion of desert hunt scenes is very low considering the prolific illustration of daily life as known from the first half of the 18. Dyn. Fishing and fowling in the Valley swamps or hunts upon hippopotamus and the Ur have instead received greater attention. The great number of ostrich representations also points in the same direction : *the larger mammalian fauna of the Nile Valley or its immediate vicinity had been widely exterminated by c. 2350 through human agency*. This does not alter the fact that the extermination of the savanna fauna in Egypt as a whole was climatically instigated. It is obvious to everyone that none of these animals could exist in the dry country to-day, whereas the galeria zone could, of course, without Man, still support them.

The animals depicted on 6. Dyn., Middle and New Kingdom reliefs *and paintings were chiefly drawn from the Red Sea Hills, southern Nubia or the steppe country of the Mediterranean littoral to be hunted in game parks and enclosures* (Butzer 1959*c*, p. 58-59, 66-67). Apart from such

(1) Includes *canidae*, hyaenas, wild ass, boar and *Bos primigenius*.

(2) Known from rock-drawings in Predynastic times.

especially popular game as ostrich or fallow deer, or symbolical hunts on lion, *the dynastic representations provide an invaluable record of the main faunal trends in Egypt as a whole.* Before the close of the subpluvial the main elements of the fauna were common to both the riverain zone and the desert highlands, after the close of the subpluvial the fauna was drawn solely from the highlands. So an essential continuity is preserved within the record.

The Vegetation of the Low Desert in late Prehistoric Times.

In view of the geological and zoological evidence of the Neolithic subpluvial one may ask whether then there is no botanical evidence, for, after all, the savanna fauna presupposes a certain amount of vegetation. This is also the case. There is considerable evidence of tree-growth on the low desert—naturally of a parkland character and limited to edaphically favoured localities—a condition substantiated by historical documentation on 5. Dyn. reliefs.

Between Khawalid and Deir Tasa (G. Brunton 1937, p. 67-68) reported tree roots in the low desert at many places. As far as can be guessed now, these were buried under scree or cultural debris. The trees included acacias or tamarisks with trunks up to 32 cm across and roots up to 4.5 m long. They can be dated from the Badarian to at latest the 4. Dyn. Since the lowest roots were found up to 12 m above the present flood-level, it is not warranted to suppose that moisture was derived from Nilotic groundwater or floodwater. Similarly at Armant (Mond and Myers 1937, p. 7-8). Here the former growth of sparsely set trees seems to have been mainly pre-Gerzean, while one tree thrived during the alluviation of a small wadi in Predynastic times—implying atmospheric moisture. The very fact that such a tree was not overly large, despite its long period of growth, indicates that we are dealing with desert vegetation. Species include *Ficus sycomorus* and *Acacia* sp. Acacias only require little moisture to establish themselves. After a few years it seems that the leaves can draw moisture from the air (M. Kassas, G. W. Murray) so as to be able to live without soil moisture for several years. For example the acacia bushes of the Eastern Desert bloom even in years

without any rains (G. W. Murray). If we assume a rainfall of 50 mm for the hillier country for the period c. 5000-3000 B. C. (cf. Butzer 1958*a*, Map 3), it is thoroughly reasonable that a limited tree-growth, in the sense of an 'acacia desert grass' savanna (H. L. Schantz), was possible in topographically and edaphically selected areas.

This interpretation of the tree remains of the low desert is substantiated by the desert hunting scenes depicted on 8. and 6. Dyn. but no later reliefs. The tomb of Ptahhotep I at Saqqara (Davies 1900, I, 21) shows an irregular low desert terrain with sycomore and smaller bushes. Again the chamber of the annual seasons in the Re temple of Neussere (Schaefer 1942, p. 256), also 5. Dyn., shows a low desert landscape with two large sycomores and a small acacia (Pl. 2), along with a number of other plants which are also visible in Sahure (Borchardt 1913, II, 17) and Mereruka (Wilson and Allen 1938, p. 25). Some of these smaller shrubs are probably desert succulents, in part perhaps also halfagrass. Their size, admittedly a poor criterion on Egyptian drawings, never exceeds the height of the antilopes' knees (c. 40 cm), But the conventionalization and simplification of detail is so strong that Prof. (Mrs.) Täckholm does not believe a safe identification to be at all possible (personal communication). The youngest of such representations is what may be a bare acacia stem in a desert scene in the 6. Dyn. tomb of Zau at Deir el Gebrawi (Davies 1902, I, 11). Each of these representations indisputably refers to the desert as the irregular, bumpy terrain is amplified by dotting—indicating sand—and red colour. In other words *the low desert was not an all-out desert in Predynastic and earlier Old Kingdom times but harboured an acacia desert grass savanna vegetation.* This sparse growth of sycomore, acacia and tamarisk in an open parkland with grass tufts and desert shrubs was due to the infrequent but ecologically important rains characterizing the subpluvial. Just as the acacias of the Eastern Desert to-day, such copse would be concentrated near wadis or even in them, where ground moisture could carry over many months from the occasional spates. As a matter of interest inscriptions record that acacia wood for *shipbuilding* (!) was felled at Hatnub even in the 6. Dyn. (Breasted 1905, I, 233). The occasional acacia bushes of this area are hardly even worth the while for firewood to-day.

We have, in summary, reviewed the geological, zoological, botanical and historical evidence for the Predynastic and early Old Kingdom period and come to the conclusion that the epoch c. 5000-2350 B. C. was considerably moister than to-day [1]. It was not an outspoken pluvial phase, but a geological record does nevertheless exist. Maximum moisture had been achieved before the Nagada I (Amratian) period, and two very intense dry spells are attributed to the transition Nagada I/II (c. 3700 B. C.) and the 1.-3. Dyn. (2850-2600 B. C.). With the 5. Dyn. the rains had pretty well ceased and the beginning of the 6. Dyn. (c. 2350 B. C.) safely marks the final termination of the subpluvial. The vegetation, in as far as it was not eradicated by Man or his herds, was able to persist a little longer. In Fig. 4 we have attempted a—purely hypothetical—reconstruction of the ecologic zones as a function of rainfall and pasture for the optimal part of the subpluvial. On the basis of the rock-drawings (see Butzer 1958*a,* Map 3) and similar botanical evidence the ecologic zones have been sketched for the Sudan as well. So for example there are innumerable dead acacia stems west of Bir el Atrun, northern Darfur (Murray 1951). There is no certain dating, but in all probability these features are contemporary. Significantly the stumps, up to 30 or 40 cm in diameter are sparsely set at about 3 to 5 per acre, which infers an open savanna vegetation some 200 km further north than this vegetation type flourishes to-day.

This then is the picture of the Nile Valley and of the Egyptian deserts in Neolithic and Chalcolithic times which the natural-historical evidence can provide. Just as the floodplain habitat was of relevance to the earliest agricultural settlement and to the development of an agrarian economy as a whole, so the former vegetation of northwestern Egypt, the Eastern Desert, the Saharan highlands and the northern Sahel was

[1] It seems unnecessary to mention that the Sahara is a natural and not a man-made desert; it is a function of the primary and secondary circulation of the atmosphere. A mere glance at the precipitation means—Alexandria 201 mm, Cairo 33 mm, Fayum 8 mm, Asyut 4 mm, Aswan 1 mm—should convince even the most sceptical desert optimist. Rich vegetation such as that of the Gebel Elba to-day is a matter of condensation moisture, mist-oases in the sense C. Troll, M. Kassas and M. Drar.

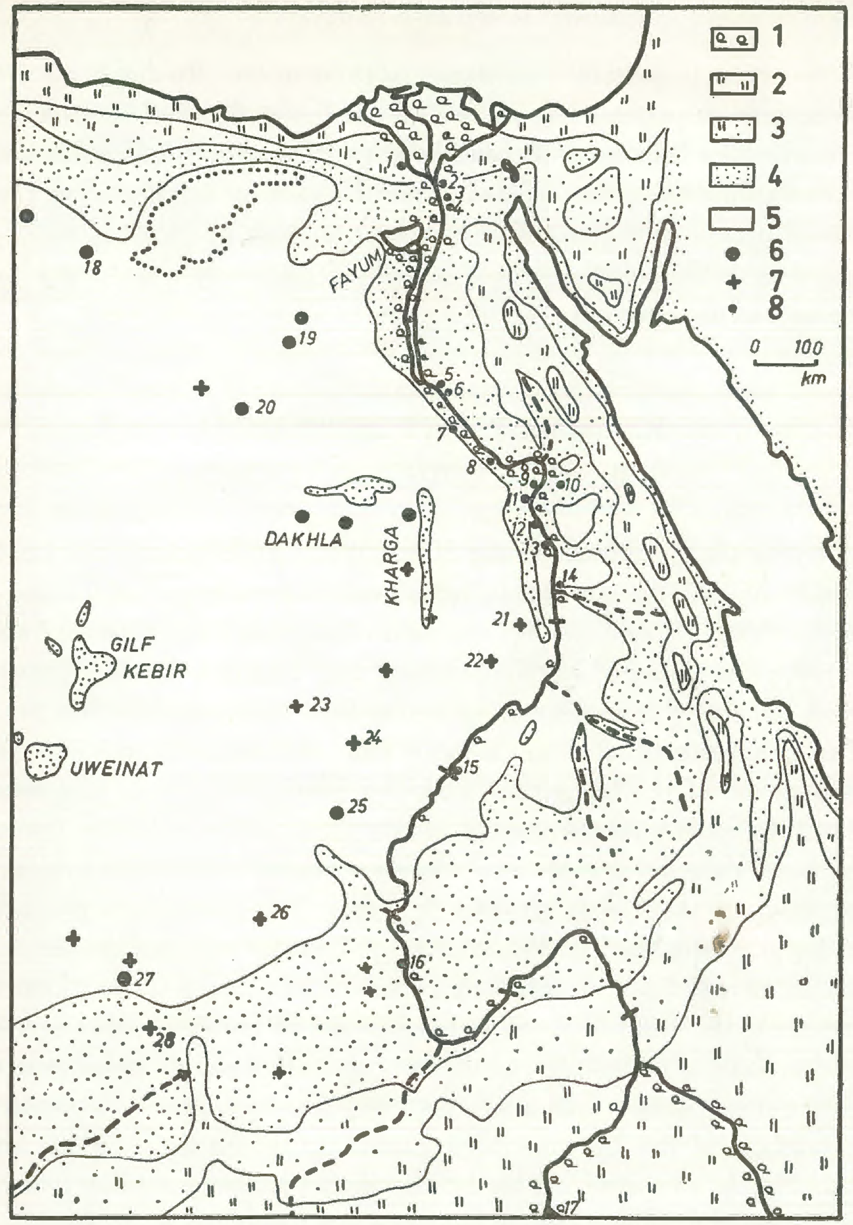

Fig. 4.—*Climatic-ecologic vegetational Zones in Egypt and the Sudan c.* 5000-3000 B. C. 1 = Galeria woodland, 2 = 'good' pasture with over 150 mm precipitation, 3 = 'moderate' pasture with c. 100-150 mm precipitation, 4 = pasture after rains, 50-100 mm precipitation, 5 = negligible pasture, less than 50 mm precipitation; 6 = larger oases, 7 = larger water places, 8 = prehistoric sites : 1 Merimde, 2 Heliopolis, 3 Maadi, 4 Helwan, 5 Deir Tasa, 6 Badari-Hemamieh, 7 Mahasna, 8 Abydos, 9 Nagada-Tukh, 10 Laqeita, 11 Armant, 12 Esna, 13 Edfu, 14 Kom Ombo, 15 Wadi Halfa, 16 Dongola, 17 Khartum, 18 Siwa, 19 Bahariya, 20 Farafra, 21 Kurkur, 22 Dungul, 23 Tarfawi, 24 el Sheb, 25 Selima, 26 Lagia, 27 Merga, 28 Bir el Atrun.

all-important to pastoral subsistence in those areas. To-day there are no nomads or pastoral folk on the Libyan Desert flanks of the Nile or in the Red Sea Hills north of about the Wadi Qena. But in late prehistoric times the Nile Valley was exposed to possible strife or invasion along the greater part of its course. This brings us to those problems of prehistorical or anthropological affinity which are intimately associated with the natural environment.

B. COMMENTS ON PREHISTORICAL AND ANTHROPOLOGICAL ASPECTS

During the dominance of the Middle Palaeolithic culture in north-eastern Africa, Man was able to settle over the greater part of the now-empty Sahara. Levalloiso-Mousterian artefacts have been collected from between the dunes of the Libyan sand sea, from the Libyan Plateau many miles away from the river as well as from the coast of the Red Sea. This is not surprising as this industry more or less corresponded to the main phase of the last great, Würm-age pluvial throughout the Near East. In relative contrast to this stands the distribution of the Upper (or Late) Palaeolithic industries, which are limited to the Mediterranean littoral or to the vicinity of wadis or rivers. This is strikingly the case in Egypt, where the Late Palaeolithic Epi-Levallois cultures, developing autochtonously from the late Upper Levalloisian, are so far not known outside of the Nile Valley. Of course it is not all too easy to distinguish surface finds of both stages, as the later product is simply characterized by a number of new innovations occurring side by side with the older.

Artefacts of the Epi-Levallois I (including the Lower Sebilian) are found in the silts overlying the late Levallois ('Mousterian') Nile gravels in Upper and Nubia, and on the shores of the + 28 m Fayum lake. Interestingly the Sebilian silts at Armant contain intercalations of aeolian sand (Sandford and Arkell 1933, p. 47), suggesting an arid local climate. Similarly the silts are not intercalated with local gravels at the mouth of Wadi Khuzam (Butzer 1959*a*), indicating little water action at the time. The Epi-Levallois II culture is generally distributed

upon the silts of southern Egypt (Sandford and Arkell 1933), occurs in and upon wadi gravels in the Thebaid (Butzer 1959*a*), in suballuvial gravels in Middle Egypt (Sandford 1934) and along the shores of the + 22-23 m Fayum lake (Sandford and Arkell 1929). The 'sub-microlithic' implements of the Epi-Levallois III stage are confined to the silt banks of the Nile between Wadi Halfa and Ezna, sites such as Dibeira West, Kom Ombo, Sebil and near Edfu (Sandford and Arkell 1933, p. 79-80, 94; E. Vignard 1924). Probably also of Epi-Levallois affinity is the industry with double-ended and discoidal cores found at Abu Suwair (Wadi Tumilat) by S. A. Huzayyin (1952), possibly also the less apparent industry at Heliopolis which includes bifacial axes and reedged flakes—unfortunately not yet published with illustrations. Although wadi gravels were still deposited with unrolled Epi-Levallois II artefacts (Butzer 1959*a*), the last stages of that cultural evolution took place during a fully arid climate while the Nile was degrading in response to a marine regression. The Abu Suwair and Heliopolis industries presumably corresponded to a postpluvial moist spell indicated from elsewhere in the Near East (Butzer 1958*b*, p. 104 seq.).

The so-called full microlithic facies grouped under the term Helwan culture, and seemingly representing the Upper Natufian, have been but incompletely studied and published so far. There is little doubt that they are chronologically Holocene and it may be justified to group them as 'Mesolithic' on considerable grounds. Best known are the finds at Helwan (Sandford 1934, p. 119-120), equally important are those of el Omari (F. Debono 1948) and Lateiqa Wells (Debono 1951). This is all we know at the moment. It seems then that the representatives of this culture were grouped on the immediate borders of the Nile or at other sources of perennial water, as were their predecessors of the Epi-Levallois III. It is implicit that the Epi-Levallois II is at least as old as the Würm maximum (c. 20,000 B. C.) on account of the corresponding cool-moist climate in Egypt (Butzer 1959*a*). This means that Man had been predominantly settled in the Valley since at least 25,000 B. C., exclusively so since perhaps 15,000 B. C. In other words *Man had moved into the riveraine zone some 10 to 20 millenia before the advent of the Neolithic.*

Yet authors like V. G. Childe (1929, p. 42, 46) speak of *postglacial* (?) desiccation as a motive to first settlement in the riveraine zone, out of which sprang the Neolithic culture : «Animals and man would be herded together round pools and wadis that were growing increasingly isolated by desert tracts and such enforced juxtaposition might almost of itself promote that sort of symbiosis between man and beast signified in the word domestication.» Or as Arnold J. Toynbee, following Childe, expresses the concept of climatic challenge (1935, I, p. 305), «When the grasslands overlooking the lower valley of the Nile turned into the Libyan Desert..., these heroic pioneers—inspired by audacity or despara-tion—plunged into the jungle-swamps of the valley-bottoms, never before penetrated by Man, which their dynamic was to turn into the Land of Egypt...» All that we can say to these genial hypotheses is, that at least ten thousand years of «juxtaposition» preceded actual incipient domestication in the Nile Valley, and that Man was living equally as long, apparently contented and undynamic, in that same supposedly uninhabitable zone before he finally embarked upon the road to civilization. Neither can we follow such arguments such as those of H. Frankfort (1956, p. 29), «... progressive desiccation marked the period from perhaps 7000 B. C. onwards ... making the valleys of the great rivers inhabitable. When meadows and shrub lands began to emerge from the swamps and mudflats along the river courses, man descended from the highlands.» Local desiccation does not effect the landscape of the floodplain of an exotic river such as the Nile, where meadows and shrub lands were characteristic on the natural levees and the only seasonally flooded alluvial flats from the very beginning. The almost classic phrase of Man's descent from the highlands is also trite and mythological. From the Lower Palaeolithic onward Man was at home upon the desert and beside the wadis and rivers. During drier phases he concentrated near the latter, so for example since the close of the Middle Palaeolithic as we saw. The common misunderstanding of human settlement «high up» on the Pleistocene terraces and his subsequent «descent» on to the alluvial flats implies a lack of basic information on the significance of river terraces, little more.

What then do we know about the transition Mesolithic/Neolithic in Egypt? In the main, that there is a great cultural gap between the terminal food-gatherers responsible for the microlithic Helwan industry and the autochtonous village farmers of late Neolithic Merimde. The cultural stages of «vegeculture» and «incipient agriculture», as Braidwood and Reed (1958) designate the mixed food-getting and specialized food-collecting transitions, are missing. This is of paramount weight in asessing the origin of the Egyptian Neolithic : we can safely assume a cultural infusion of some sort from the Fertile Crescent where this transition of cultures has been demonstrated. Until further evidence is available it remains a supposition however. Suffice it to say that Merimde appears well after the onset of the Neolithic subpluvial c. 5000 B. C. (at least two millenia later than the earliest farming communities in the Fertile Crescent) and that Late Glacial—Early Postglacial aridity did not promote the transition from food-gathering to food-producing in any way, nor did it motivate Man to first settle in the riveraine zone or begin the process of (initially unnecessary) swamp-drainage. Late Pleistocene aridity only provided a latent means of enforced habitation of the ever-optimal zone of population concentration nearby to rivers or wadis—at least ten millenia before the beginnings of local agriculture.

Quite contrary to the desiccation or river-propinquity theory of Neolithic origins, desert settlement achieved a quite unknown density and importance just after the transition to food-producing. Innumerable Neolithic and especially Chalcolithic sites are still preserved along the desert margins of the Valley from Merimde to Upper Nubia, Still lacking systematic study are further the wealth of New Stone Age artefacts seemingly scattered over the desert surfaces of the greater part of Egypt. These do not only occur at oases such as the Gilf Kebir and Kharga but along the routes across the Libyan Desert. Apart from the stone industries are the rock-drawings of the Eastern Desert of Upper Egypt, the Wadi Kharit area of southeastern Egypt, the flanks of the Upper Egyptian Valley, the great oasis, and the plateaux of the Libyan Desert. Hans Winkler identified six ethnic groups on the basis of the rock pictures and drawings. Most important of these are : 1) the Earliest Hunters, contemporary to

the Egyptian Neolithic and Amratian cultures and originally living in the desert areas of the south half of Egypt. They were hunters and little else, we have no evidence that they kept domesticated animals. So far we have no implements linked with them, and it may be that they had so-to-speak a Mesolithic rather than a Neolithic culture. It is widely assumed that the cultural impetus to rock-drawings originated in the northwestern Sahara, under influence of Mesolithic Spain. 2) The so-called autochtonous mountain dwellers, a cattle-herding folk appearing in Amratian times and probably the forebears of the hamitic Bidjarin of Upper Egypt. These settled in the hunting grounds of the Earliest Hunters and gradually seem to have absorbed these. 3) The Early Nile Dwellers, who seem to have been the major protagonists of the Gerzean culture, and are linked with the so-called Nagada boats. These people drew boats, hippos, and crocodiles in Wadi Hammamat, and it may be that they already carried out commerce and trade on the Red Sea routes.

Figuratively speaking there was apparently an explosion of population after c. 5000 B. C. paralleled by new settlement through the greater part of the Sahara. The latter is certainly not a matter of greater carrying-capacity of a food-producing economy. The explanation must be sought in a climatic amelioration, an interval of some rain throughout the more elevated areas of the Sahara with a differentiated relief and topography. This was realized already 30 years ago on the basis of the fauna of the petroglyphs.

The Late Palaeolithic and Mesolithic saw the desert Sahara next to uninhabited, with the advent of the first farming communities in the Nile Valley the desert highlands were repopulated by Man, who apparently followed the game inwards from the latitudinal fringes of the Great Desert. The 5th millenium saw a loosely affiliated cultural group of Early Hunters occupying the Saharan highlands from the Atlantic to the Red Sea. The fine naturalistic drawings of large dimensions are however not common to the Earliest Hunters of Upper Egypt and Uweinat. Possibly these formed a local group. The lack of drawings of the hunting culture on the southern and northeastern borders of the Sahara suggests the original cultural connexion was possible straight across the centre of the desert complex. However the minuter problems of the origins and ethnic classification of the ancient Saharan populations are not our matter, we are only concerned with the ecologic problems they pose (similarly so our discussion of these people in Butzer 1958*a*, p. 40-47).

The second group of desert folk, the cattle-nomads of Hamitic affinity, originated somewhere in the southeastern Sudan it seems, and spread northwards to the Red Sea Hills and to Uweinat, and northwest-wards through the Central Sahara to the Fezzan, Tassili, Hoggar, Air, Nigeria etc. One gets the impression of a radial expansion from the axis Ennedi—Tibesti—Tassili—Hoggar, which would seem ecologically feasible. This livestock-raising culture was able to flourish in the central Saharan hill country during the 4th and 3rd millenia. Whether these two great peoples were actually limited to the domain of the rock-drawings or whether the rock-drawings were limited to areas with suitable material (exposed, flat rock surfaces of some durability, yet not too hard) remains a puzzle. Interestingly the sites west of Luxor (see Winkler 1938-1939) are on limestone rock faces, so that not only sandstone was used. In a very broad way the limits of the rock-drawings do probably reflect ethnic lines to some extent. Fig. 5 gives a broad outline of the localization of these two peoples.

Besides these folk who left us a vivid record of their way of life there were of course others who left the mute surface finds of stone implements and pottery. From them we know of prehistoric agriculture in the Kharga and elsewhere in the Libyan Desert, so the querns and grinders from Uweinat. But until this scattered material is all gathered, particularly from the Red Sea Hills, and published, we can say little else than that numerous but unknown peoples inhabited the greater part of Egypt in Predynastic times. We need only refer to the nation of the Temehu Libyans who inhabited the oases during the Old Kingdom—all before the close of the Neolithic subpluvial. The termination of better climatic-ecologic conditions in the Sahara led to the evacuation of Tibesti, Uweinat, the Gilf Kebir and part of the Libyan oases well before the last millenium B. C., the historical repercussions being well known from Egypt in the 6. Dyn. for example. Desert neighbours play no part whatever for Upper Egypt during the New Kingdom, nomadic strife

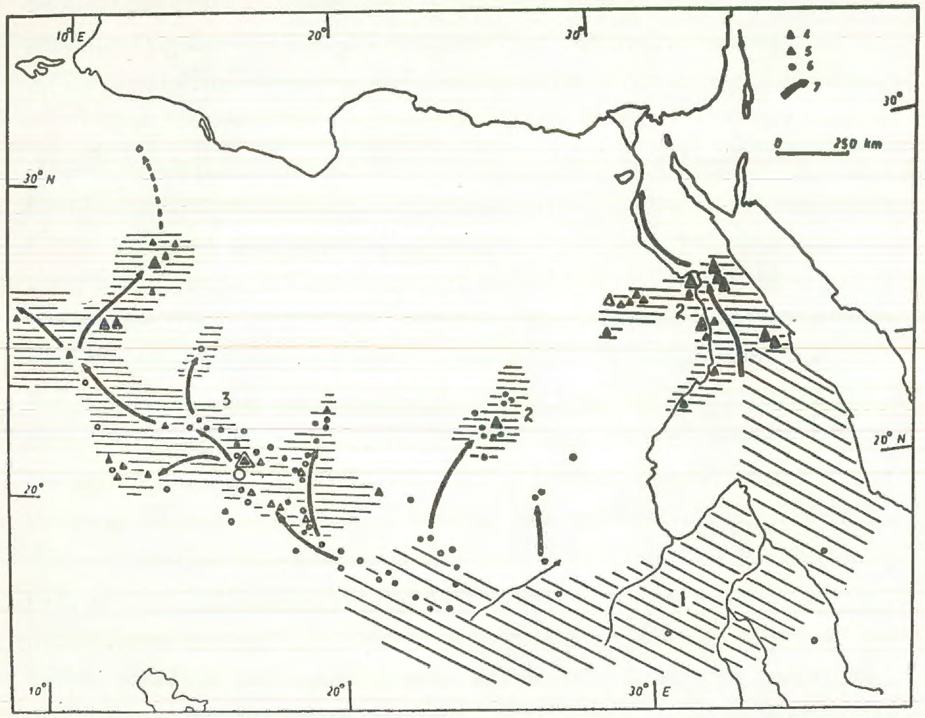

FIG. 5.—*Early Hunters and Cattle-nomads in the Sahara in Neolithic Times.* 1 = approximate extent of 'Hamitic' livestock-raising culture c. 4000 B. C. 2 = documented extent of the eastern Hunters at that time, 3 = domain of central group of Hunters, 4 = rock-drawings of Early Hunters, important centers shown by larger symbols, 5 = rock-drawings of the Early Hunters and Cattle-nomads, 6 = rock-drawings of the Cattle nomads; 7 = hypothetical routes followed by the expending Cattle-nomads in the 4th millenium B. C.

being limited to the steppe littoral of the Mediterranean. After the arrival of the camel the Blemmyan wars against Rome document the persistance of nomads only in the present lands of the Ababda, Beja and Bidjarin. Desert inhabitation and cultural intercommunication across and through the Sahara achieved a unique maximum in Neolithic times the course of the subpluvial c. 5000-2350.

The rather sudden and dramatic expansion of the food-producing Neolithic cultures—existing in the Fertile Crescent since at least 7000B.C. across the Middle East, via Anatolia to southeastern Europe, through the Mediterranean, and over Egypt to the Sahara coincides remarkably

well with the onset of moist conditions after 5000 B. C. One cannot help but believe that the same ecologic conditions enabling the savanna fauna to occupy the Saharan highlands facilitated and perhaps inspired Man's expansion over the great Empty Quarter and the spread of the numerous farming population throughout the arid zone of the Old World.

The writer is indebted to G. Erdtmann (Stockholm), G. Haeny (Cairo), H. W. Helck (Hamburg), W. Kaiser (Heidelberg), G. W. Murray (Aberdeenshire), K. S. Sandford (Oxford), G. Smolla (Frankfurt) and (Mrs.) Vivi Täckholm (Cairo) for kindly supplying information employed in this essay.

LITERATURE CITED

AMER, M. and HUZAYYIN, S. A. (1952). Some physiographic problems related to the predynastic site of Maadi. *Proc. Panafrican Congr. Prehist.* (Nairobi 1947), Oxford, pp. 222-224.

ARKELL, A. J. (1949). *Early Khartoum.* Oxford.

—— (1949*b*). The Old Stone Age in the Anglo-Egyptian Sudan. *Sudan Antiquities Serv. Occ.* Papers 1, 52 pp.

—— (1953). *Shaheinab.* Oxford, 116 pp.

AWAD, HASSÂN (1959). Water resources of Egypt—problems and realizations. Colloquium, *Geographisches Institut der Universitat Bonn,* May 15.

BADAWY, A. (1954). *A History of Egyptian Architecture,* Cairo. vol. I.

BALL, J. (1939). *Contributions to Geography of Egypt.* Cairo.

—— (1942). *Egypt in the Classical Geographers.* Cairo (edited by G. W. Murray).

BOESSNECK, J. (1953). Die Haustiere in Alt Ägypten. *Ver. Zool. Staatssamml.* München 3, 1-50.

BORCHARDT, L. (1913). *Das Grabmal des Königs Sahure.* Leipzig, 2 Bde.

BRAESTRUP, F. W. (1947). Remarks on faunal exchange through the Sahara. *Vidensk. Medd. fra Dansk natur. Foren.* 110, 1-15.

BRAIDWOOD, R. J. and REED, C. A. (1957). Achievement and early consequences of foodproduction : a consideration of archeological and natural-historical evidence. *Cold Springs Harbour Symposia on Quant. Biol.* 22, 19-31.

BREASTED, J. (1906-1907). *Ancient Records of Egypt.* Chicago, 7 Vol.

BRUNTON, G. (1937). *Mostagedda and the Tasian Culture.* London.

—— (1948). *Matmar.* London.

—— and CATON-THOMPSON, G. (1928). *The Badarian Civilization.* London.

BUTZER, K. W. (1958*a*). Studien zum vor- und frühgeschichtlichen Landschaftswandel der Sahara I. : Die Ursachen des Landschaftswandels der Sahara und Levante seit dem klassischen Altertum. II. : Das ökologische Problem der

neolithischen Felsbilder der östlichen Sahara. *Abh. Akad. Wiss. Liter. Math.-naturw. Kl.* Nr. 1. 49 pp. Franz Steiner Verlag, Wiesbaden.

BUTZER, K. W. (1958*c*). Quarternary Stratigraphy and Climate in the Near East. F. Dümler Verlag, Bonn. *Bonner Geographische Abh.*, Bd. 24, 157 pp.

—— (1959*a*). *Contributions to the Pleistocene geology of the Nile Valley. Erdkunde* 13, 46-67.

—— (1959*b*). Some Recent geological deposits of the Egyptian Nile Valley. *Geogr. Journ.* 125, 75-79.

—— (1959*c*). III. : Die Naturlandschaft Ägyptens während der Vorgeschichte und der Dynastischen Zeit. *Abh. Akad. Wiss. Liter. (Mainz) Math.-naturw. Kl.* Nr. 1. 80 pp. Franz Steiner Verlag, Wiesbaden.

—— (1959*d*). *On the Quarternary shorelines of Arabs' Gulf.* In print.

CHILDE, V. G. (1929). *The Most Ancient East.* London, 4. Edition 1952.

DAVIES, N. de G. (1900). *The Mastaba of Ptahhetep and Akhetep at Saqqareh.* London, 2 vol.

—— (1902). *The Rock Tombs of Deir el Gabrawi.* London.

DEBONO, F. (1948). El Omari (près d'Helouan). *Ann. du Service* 48. 561-569.

—— (1951). *Ann. du Service* 51.

FOURTAU, R. (1915). Contribution à l'étude des depôts nilotiques. *Mém. Inst. d'Egypte* 8, 57-94.

FRANKFORT, H. (1956). *The Birth of Civilization in the Near East.* New York.

GARSTANG, J. (1903). *Mahasna and Bet Khallaf.* London.

HAFEMANN, D. (1959). Die Frage des eustatischen Meeresspiegelanstiegs in historischer Zeit. Vortrag 32. *Deutscher Geographentag*, Berlin. In print in the Proceedings.

HUZAYYIN, S. A. (1941). The Place of Egypt in Prehistory. *Mem. Inst. d'Egypte* 41.

—— (1952). New light on the Upper Palaeolithic of Egypt. *Proc. Pan-African Congr. Prehist. Nairobi* (1947), Oxford., pp. 202-204.

JUNKER, H. (1929). Vorberichte über die Grabungen auf dem vorgeschichtlichen Merimde-Benisalame. *Anz. Akad. Wiss. Wien, Phil.-hist. Kl.*, 156-248; 1932, 36-97; 1940, 3-25.

KAISER, W. and BUTZER, K. W. (1959). Bericht über eine geologische-archäologische Felduntersuchung in Ägypten 1958. *Mitt. deut. arch. Institut, Abt.* Cairo, 17.

KEES, H. (1954). *Das alte Ägypten.* Berlin.

KNETSCH, G. (1954). Allgemein-geologische Beobachtungen aus Ägypten (1951-1953). *Neues Jb. Geol.* 99, 287-297.

LARSEN, H. (1957). On the detail of the Naqada Plant. *Ann. Service* 54, 230-244.

LEES, G. M. and FALCON. N. L. (1952). The geographical history of the Mesopotamian plain. *Geogr. Jour.* 118, 24-39.

MENGHIN, O. and AMER, M. (1932). *The excavations of the Egyptian University in the neolithic site at Maadi* (1930-1931). Cairo.

MOND, R. and MYERS, O. H. (1937). *Cemeteries of Armant I.* London, 2 Vol.

MURRAY, G. W. (1951). The Egyptian climate : an historical outline. *Geogr. Journ.* 117, 422-434.

PASSARGE, S. (1940). Die Urlandschaft Ägyptens und die Lokalisierung der Wiege der altägyptischen Kultur. *Nova Acta Leopoldina* 9, 77-152.

PEET, T. E. (1914). *Abydos.* London.

PETRIE, W. F. and QUIBELL, J. E. (1896). *Nagada and Ballas.* London.

SAID, R. (1953). Remarks on the geomorphology of the area east of Helwan. *Bull. Soc. Géogr. d'Egypte* 25.

SANDFORD, K. S. (1934). Paleolithic Man and the Nile Valley in Upper and Middle Egypt. *Univ. Chicago Orient. Inst. Publ. (UCOIP)* 18.

—— (1936). Observations of the distribution of land and freshwater mollusca in the southern Libyan Desert. *Q. J. Geol. Soc.* 91, 323-381.

—— and ARKELL, W. J. (1929). Paleolithic Man and the Nile-Faiyum Divide. *(UCOIP)* 10.

—— (1933). Paleolithic Man and the Nile Valley and Uppper Egypt. *(UCOIP)* 17.

—— (1939). Paleolithic Man and the Nile Valley in Lower Egypt. *(UCOIP)* 49.

SCHAEFER, H. (1942). Die Kunst des Alten Orients. *Ägypten. Propyläenkunstgeschichte*, Vol. 2. 3rd Edn. Propyläen-Verlag, Berlin.

SCHWEINFURTH, G. (1884). Pflanzenreste aus altägyptischen Grabern. *Ber. deut. botan. Ges.*, Berlin, 357-396.

SHAFEI, A. (1952). Lake Mareotis, its past history and future development. *Bull. Inst. Desert II*, 1, 71-89.

SHUKRI, N. M. and AZER, N. (1952). Mineralogy of Pliocene and more recent sediments in the Fayum. *Bull. Inst. Desert II*, 1, 10-53.

SIMAIKA, Y. M. (1953). The suspended Matter in the Nile. Cairo. *Phys. Dept.* Paper 40.

TACKHOLM, VIVI and DRAR, M., with TACKHOLM, G. : *Flora of Egypt.* Cairo I. (1941), II. (1950), III. (1954).

TOYNBEE, A. J. (1934 *ff*). *A Study of History.* London, 10 Vol.

WILSON, J. A. (1955). Buto and Hierakonpolis in the geography of Egypt. *Jour. Near Eastern Studies* 14, 209-236.

—— and ALLEN, T. G. (1938). The Mastaba of Mereruka. *(UCOIP)* 31, 3 Bde.

WINKLER, H. A. (1938-1939). *Rock-Drawings of Southern Upper Egypt.* London, 2 Vol.

PHOTO 1. Breccia of cemented limestone scree above Predynastic cultural deposit near Badari, indicating considerable humidity at time of consolidation.

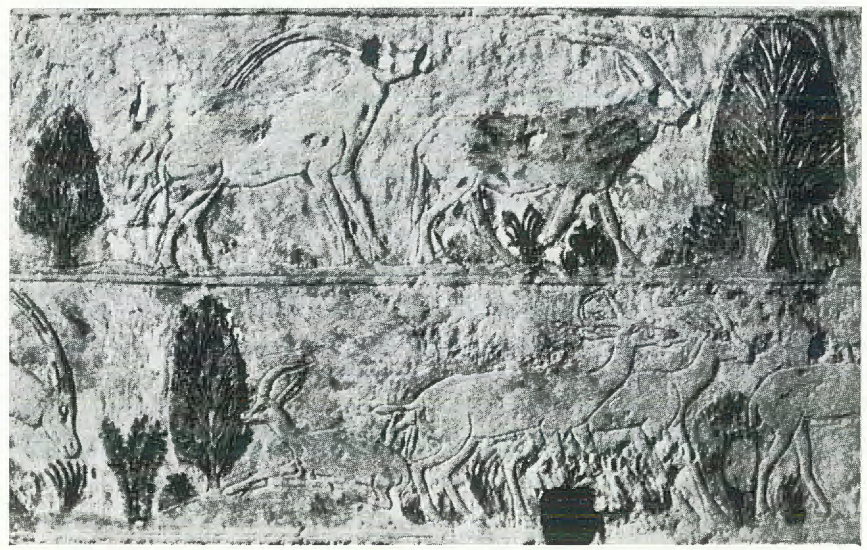

PHOTO 2. Life on the Steppe, from the Temple of Neussere at Abusir (after H. Schaefer 1942, Pl. 256) with kind permission of the Propyläen-Verlag, Berlin. Upper panel, from l. to r. : acacia *Oryx algazel, Addax nasomaculatus,* sycomore. Lower panel : head of oryx, sycomore, reclining *Gazella dorcas, G. dorcas isabella, G. dorcas,* and rear of another gazelle.

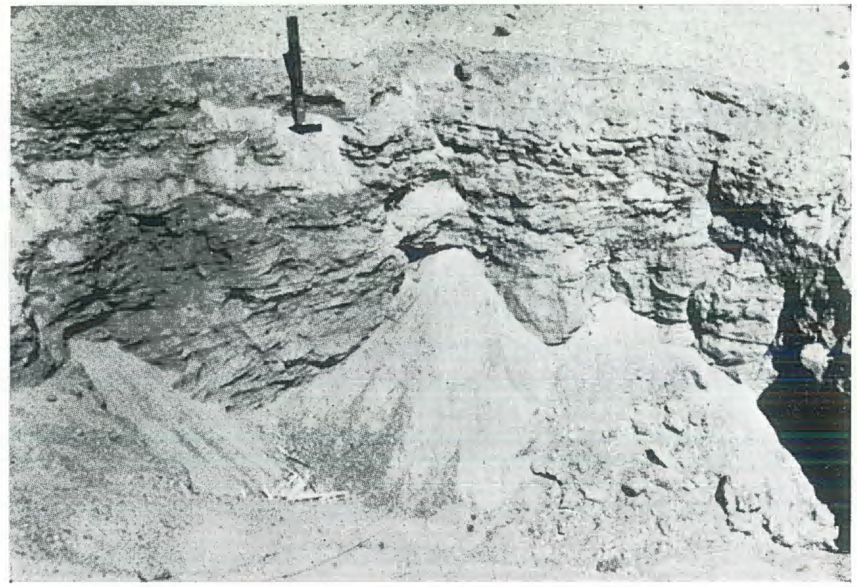

Photo 3. Falsebedded deposit of sand and silt upon Gerzean settlement at Hierakonpolis, indicating considerable local aeolian denudation and redeposition of the Sebilian silts in post-Nagada times.

Photo 4. Nilotic silt (20 cm) of Islamic age bedded between aeolian sand at el Ansar, near Meir. Dune (2 m) bordering fields in background (see fig. 2).

SOME ASPECTS OF THE URBAN GEOGRAPHY OF THE KHARTOUM COMPLEX

BY

GAMAL HAMDAN

I. SITUATION, SIZE AND FUNCTIONS OF THE THREE TOWNS

I. Situation.

To analyse the situation of the Triple Capital one has to consider a map of the distribution of population in the Sudan. Such map shows that, in terms of population densities and urban scatter, the humanly effective Sudan, its « oekumene », consists of 2 axes. The major, transversal axis is the savanna belt, stretching from Darfur across Kordofan and the Gezira to the Red Sea mountains. It contains a whole network of nodal, major towns overlying a fairly dense, continuous sheet of population. Essentially the settlement belt, it is likewise the Nilotic sector of the continental mobility belt, the trans-continental « Durchgangsland », the « African Broadway »[1] so-called, or, better still, its « Bush Lane ». The second axis, minor only in extent, is longitudinal and cuts across the other : the Nile valley. It varies appreciably in its human weight along its various sectors, being much less important across the sparse, forbidding north desert, as well as through the « Sudd » impasse in the south. It is really important only along its median White Nile sector. Where the two axes cross and fuse there is produced the most important part of the Sudan oekumene—its « nuclear core » so to speak. And it is at the heart, or rather the head, of this core that

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[1] J. Fairgrieve, *Geog. and World Power*, Lond., 1941, p. 278.

Khartoum is situated; at the confluence of two, in fact three, major arterial rivers. The situational advantages are thus vitally evident. A desert-savanna border-town, a link in Vidal's famous circum-desert urban bead-string, it is a focal intermediary between regions of contrasted production. A confluence town (the northernmost tip peninsula at the junction of the White and Blue Niles is significantly called the Mogren, i. e., the confluence), it is necessarily a break-of-bulk and a trans-shipment point. It has traditionally been the head of navigation up the White Nile. Oekumenically and physiographically, then, the position of Khartoum is well-endowed.

There is, however, another territorial viewpoint to consider—the political framework of the state. It is evident that, when founded capital, the site of Khartoum was chosen with reference to a political frame different from that of present-day Sudan. An Egyptian province, the capital was logically located as near as was oekumenically possible to the «mother» country; something like a southern outpost. As Walkley puts it, «Khartoum was about the farthest limit of Egyptian rule, such as it was»[1]. The situation has since materially changed. The swift southward swing of the political frontier, right up to the Lakes and Uganda, that is the expansion of the territorial frame of reference, together lately with the independence of the Sudan, have inescapably shaken the old space-relations. The relative centrality of Khartoum is overruled. At a distance-ratio of one-third to two-thirds from north to south, it now tends to be somewhat peripheral in the state. In a far-flung country of sub-continental dimensions, with certainly underdeveloped and almost disoriented transportation[2], but especially in an ethnically heterogeneous state beset with separatist dangers, it has in post-independence days been felt, and voiced, that the location of the capital as it is may not perhaps be the best from the point of view of the «winning of the south» and the welding together of the component regions of the country. The recent rapid growth, still more the future possibilities, of Juba would

(1) C. E. J. Walkley, «The Story of Khartoum», *Sudan Notes and Records* (henceforth S. N. R.), vol. XVIII, part II, 1935, p. 236.

(2) Robin Hodgkin, *Sudan Geog.*, 1952, p. 139.

seem to prove a remoteness and an attenuated grip of the capital. Some such place as Renk, Kosti or Sennar might plausibly be argued a more central harmoniser between north and south. In fact, Khartoum has come in recent years under much fire and criticism as capital; with some nationalist reversionists advocating Sennar as substitute for its long native history as capital of the Fung dynasty. On the other hand, however, the historical momentum gathered by Khartoum as a «going concern» has irrevocably hardened into a geographical inertia. Khartoum is the predominant urban fact in the Sudan. Contemplation of the dual system of an alternative, purely political, symbolic capital leaving Khartoum as the economic capital would ultimately undermine her inasmuch as the bulk of her raison d'être stems from the political function. The cocoon of ancillary functions is not yet heavy enough to ensure healthy survival of the organism without the primary political function. It may be added that, apart from oekumenical control, the rather peripheral position of Khartoum may be a reflection of a suspected tendency for tropical capitals (unlike colder capitals) to arise as much as possible in the most poleward sector of their countries (cf. Delhi, Cairo, Rio de Janeiro, etc.).

II. Size of the three towns.

At the time Khartoum was founded (1820-1830), Shendi, we are told, was the largest town of the Sudan, but was fatally devastated by the famous fire. Wad Medani too, was a rival claimant to be seat of capital[1]. The final selection of Khartoum also engendered the decline of Sennar[2]. Apart from the changing ranks and destinies, the story points to the Gezira region as the endemic centre of urban gravity in the Sudan. The subsequent history of Khartoum was quite chequered; it grew by fits and starts and at the Mahdist revolt was totally ruined and abandoned[3].

(1) F. A. Edwards, «Foundation of Khartoum», *S. N. R.*, vol. V, 1922, pp. 157, 161.

(2) Walkley, p. 230.

(3) C. E. J. Walkley, «Story of Khartoum», *S. N. R.*, vol. XIX, Part I, 1936, pp. 71 ff.

Omdurman, with 143.000 in 1956, and not Khartoum (99.000), is at present the biggest single town in the Sudan, and was still bigger during the Mahdism. Growth, however, being progressively monopolised by Khartoum, the latter is certain to outstrip her in the near future. The Three Towns together total some 241.000, and would thus rank with such relatively much less important places as Jacksonville, Florida (241.000 in 1950) or Port-Said. Yet this quarter-of-a million « conurbation » alone represents 37 % of the total urban population of the Sudan residing in the 16 centres of + 15.000 [1]. This total (641.000) was believed to equal one-fourteenth of the total population of the country [2]. It is instructive to relate the population of the Triple Capital to the general national population : 1/4 million out of some 10 millions, or a ratio of 1:40 against 1:5 for Cairo or London. This denotes that the immature urbanism of the Sudan is still in its infancy and far from modern centralised metropolitan organisation. With 70.000 and 57.000 respectively, Obeid and W. Medani [3] are the second and third urban centres after the Khartoum conurbation.

III. The functional bases and integration of the Three Towns.

a) *Functions*. The primary functions of the Three Towns are generally duplicated in each of them but with varying degrees of emphasis and colour. Thus while the Three Towns in general form the capital city, the political function really belongs to Khartoum. There are some extensions of the political function in both Omdurman and Khartoum North, but the role and concentration of that function in Khartoum has been definitely enhanced since independence. The dominance of the politico-administrative function in Khartoum makes her an essentially « officialdom town ». This means, inter alia, a great importance as a vast market of a high standard of living, income and consumption, a

(1) *Sudan Almanac*, 1956, p. 61.

(2) S. Fawzi, *Social Aspects of Low Cost Housing in the Northern Sudan*, Khartoum, 1954, p. 104.

(3) *Sudan Almanac*, id.

fact of great relevance in shaping the ancillary occupations as well as the outer morphology of the town as a modern «European» settlement. Commerce mainly centres in Omdurman and Khartoum, but while modern commerce with the outer world in the shape of head-offices, import and export companies, banks, agencies etc. belongs primarily to Khartoum, to Omdurman goes « native » local commerce. Omdurman is indeed the largest « African » bazaar town in the continent : the market for the whole adjacent desert region west of the Nile, a collecting centre for the desert and savanna products—hides, wool, meat, gum in return for grain and textiles from the valley. Khartoum is the focal centre for all foreign manufactured imports, and, in virtue of her location with reference to Port-Sudan, expedites most of the agricultural and raw exports of the country. In the past, slave trade was a very important activity [1]. Khartoum has of late been draining much business from Omdurman. Since independence, Omdurman businessmen and promoters have been increasingly inclined to move to Khartoum attracted by a wider clientèle of a higher standard of consumption. This bids fair to threaten the long-standing repute of Omdurman as the largest native market town in the country [2].

As to industries, it is easily a slight item in the conurbation, and quite recent too. The last war conditions forced a measure of industrialization in some basic consumers' goods, but lack of fuel has always been a handicap. Apart from traditional handicraft industries in Omdurman, the present range comprises light industries—tobacco and car repair in Khartoum, and the so-called « heavy » industries at Khartoum North—oil-seed crushing and pressing, soap making and beer.

In virtue of the excellent riverine position, the Khartoum complex has always been a nodal river-port, especially when water transport was the sole or main medium of travel. The Murada (= embarcadère) at Omdurman and the Escale at Khartoum are vestigial river-side docks from that era. Irrigation works on the rivers have been a hindrance to navigation, yet Khartoum remains the head of navigation southwards

(1) Walkley, 1935, p. 236.

(2) *Annual Report*, Khartoum Province, 1955-1956.

while Khartoum North harbours the vast state arsenal. Moreover, the railway network is pivoted on Khartoum which is the nerve-centre for transversal and longitudinal lines alike. Besides, air transport is fast making of Khartoum an international station, a vital air cross-ways in Africa [1]. This has lately been enhanced by the recently shifting values in world strategy.

Such in outline is the functional base of the Khartoum complex. While exclusive specialisation among its constituent components is ruled out, the following generalisation may not be amiss. If, with its administrative-political and commercial functions, Khartoum be the « head », Omdurman by its mass and predominantly residential character is the « body », while Khartoum North with its « heavy » industry would be the « arms ». In general, the functions of the Three Towns are truly metropolitan in that they serve the whole of the country rather than merely regional or local orbits.

b) *Functional Integration.* The question as to how far integrated the Three Towns are may be legitimately raised. The fact that Khartoum is the « office », Omdurman the « home » and Khartoum North the « work-shop » is indication enough of a good measure of functional integration. The physical separation of work-place and place of residence is bound to eventuate in a close reciprocal daily relationship—the « journey to work ». The Khartoum complex experiences a daily mutual ebb and flow very similar to that known in western metropolises and conurbations [2]. Every morning thousands of vehicles from Omdurman and Khartoum North pour into Khartoum, while a reverse current takes place in the afternoon. To be sure, there are side currents and counter-currents cutting across this basic pattern, but they are all of subsidiary magnitude compared to this tidal, pulsatory wave. A sample-census by the Traffic Dept. for 15 days in August 1956 taken at the two bottle-necks between the Three Towns (the Blue and White Nile Bridges) revealed the following situation :

[1] Hodgkin, p. 3. [2] *Ibid.*, p. 7.

Media	From Omdurman to Khartoum		From Khartoum to Kh. North	
	No. in 15 days	Daily Average	No. in 15 days	Daily Average
Cars	107,679	7,178	88,598	5,906
Bicycles	59,246	3,949	76,522	5,101
Animal-drawn Carts	3,890	259	2,299	153
Trams	2,257	150	2,938	195
Beasts of Burden	7,992	532	10,263	684

While showing a considerable volume of inter-town movement as well as the great importance of the bicycle, the figures, not being reciprocal, do not reveal much. Instead, we may gauge a sample or section of this journey as statistically inferred from the telephone directory. Enumeration of those telephone subscribers in the Three Towns whose work-place differs from their place of residence gives a sector-sample (1271 in 1956) which, though small and economically sectional, is not far from being more or less generally representative.

Work-place	Place of Residence								
	Khartoum			Omdurman			Khartoum North		
	Native	Foreigner	Total	Native	Foreigner	Total	Native	Foreigner	Total
Khartoum	352	422	744	156	8	164	26	4	30
Omdurman	11	7	18	225	51	276	—	—	—
Khartoum North	1	2	3	4	—	4	21	11	32

The majority of the sample naturally work in the town where they live, but otherwise the volume of the journey-to-work from both Omdurman and Khartoum North to Khartoum compared with its opposite current is in the ratio of 9 to 1. It is noticeable that, among the non-commuting majority, while the ratio of foreigners is extremely high in the case of Khartoum it is very insignificant in Omdurman—yet another

indication that Omdurman is no residence for foreigners, but is essentially native. It may also be added that the bulk of the Khartoum-oriented current is composed mainly of government officials and civil servants while the opposite drift mostly consists of those engaged in liberal professions and private enterprises. The conclusion, in brief, is that Khartoum is the work-place for many thousands living in Omdurman and Khartoum North, which towns are thus in a sense a commuting zone for the former. A pronounced daily range in the population of each town is well-nigh evident, but on this we have no figures. All these facts, no doubt, point to a degree of functional interdependence between the three segments of the conurbation. It is, however, hard to escape the conclusion that the morphological, organic integration, is feeble. This is basically due to the excessive horizontal sprawl of « Flattown ». This leaves the urban area very diffuse, loose and incoherent—indeed disoriented. Not only does each town lack a focal, magnetic hub, but the conurbation as a whole lacks a decisive nucleus. The Nile «Tripolis» is a vast «suburb of no city»... Outside the immediate heart of each town, the observer is struck by apparent desolation reigning supreme. The perimeter covered by the built-up area is enormous while a diagonal from the Fellata village in the extreme south of Khartoum to Abu Ruf in the northeasternmost tip of Omdurman measures, as the crow flies, some 13 km. or 7 miles [1], the actual routes being naturally longer. These are dimensions that challenge the travelling capacity of the poorer classes and, anyhow, represent a terrible « safari » under a scorching sun. As a result of this extreme straggling certain local adaptations have emerged—the unusually wide-spread prevalence of the bicycle, the unique custom of collective taxis (tarrahas) and the undue influence of taxi-drivers in civic politics! Urban sprawl is emphasised by the grid-iron planning which adds to distances and disorientation. The poor network of roads should not be overlooked; unpaved, bumpy, the streets are dusty in the dry season and hopelessly muddy in the rainy season—even when metalled, asphalt radiates heat

[1] Compare Paris with 8 miles as the greatest distance within the agglomeration. See E. A. Bergel, *Urban Sociology,* 1955, p. 47.

intensely... The lack of inter-town trunk routes is notorious; only a single artery exists between each of Khartoum and Omdurman and Khartoum and Khartoum North. Curiously, no direct land connection exists between Omdurman and Khartoum North; only is there a ferry boat and any project for a new bridge should be directed to using Tuti island as the natural connecting nexus of the Triple Capital. Until recently a toll was levied on the crossing of either of the two bridges! Finally a further severing factor is the fact that, due to a series of obstacles including extensive barracks, growth of each town proceeds away from the other, thereby dismembering the conurbation instead of fusing and welding it together. It is sometimes claimed that a deliberate policy of dismemberment was pursued by the former colonial power to isolate that fount of agitation and native politics—Omdurman. Until now, it is symptomatic that at nightfall each town is tersely shut in within its cocoon and the minimum inter-town reciprocation takes place. Hence the functional integration of the Three Towns has always been limited to the necessity minimum. The capital is a « Tripolis » not quite only in name...

II. THE POPULATION STRUCTURE OF THE THREE TOWNS.

This section discusses some demographic aspects of the native and foreign population of the metropolis.

I. The Native Population.

It suffices here to indicate their relative preponderance and regional origins [1]. At once Omdurman emerges as the native metropolis par excellence. Out of a total population of 142.619 in 1956, 8790 or 6 % were not natives. This compares with 15.5 % foreigners (15.747 out of a total of 98.707) in Khartoum and 3.5 % for Kh. North (2229 out of a total of 61.799). Omdurman is thus the largest native capital in absolute terms despite a higher native ratio in Kh. North. In view of its minimal ratio of foreigners the popular repute of Kh. North as

[1] For all following population figures, age and sex structure, see, *Ann. Rep.,* 1955-1956.

excessively foreign is a misconception, perhaps to be accounted for by the small size of the town altogether. As is expected, Khartoum has the least degree of preponderance in natives. It began, and still to a large extent remains, essentially a « ville coloniale créée »—the « European town », in sharp contrast to native Omdurman [1]. It is these varying foreign ratios that give a specific twist to each town.

As to the regional extraction of the native population, figures do not allow accuracy or detail, but apart from the fact that the base is derived from all parts of country, two facts are nevertheless evident. First, the south is not proportionately represented in the triple metropolis—the capital is essentially « northern ». The drift of southerners has been lately gaining in strength, but the back-flow is equally serious, sometimes indeed is forced [2]. Secondly, regions of human repulsion in the Sudan have a more than proportionate representation in the metropolitan structure. This refers particularly to the Northern and Red Sea Provinces. Proximity to the lure of the capital obviously joins forces with the dispersive urge of a niggardly desert—and—mountain habitat [3].

II. The Foreign Communities.

It is only too obvious that the metropolis is highly cosmopolitan. This is partly due to a long-standing foreign dual domination, partly to the fact that the foreign communities of the capital make in fact the greater part of foreign nationals in the whole country, it being a universal rule for foreigners to be heavily concentrated in capital cities. Moreover, by a deliberate policy of the dominant colonial power, the Sudan has long been an « open » country for immigrants.

The foreign communites vary in degree as well as in kind as between the three towns. Their highest ratio belongs naturally to Khartoum —one-sixth the total population, then follows Omdurman then Kh.

(1) Pierre George, *La Ville*, Paris 1952, p. 32 and Harrison Church, *Modern Colonisation*, Lond., 1951.

(2) *Ann. Rep.*, 1950-1951.

(3) *Ibid.*

North. Again, Khartoum, the modern « European » city, is the place of election of most of the « higher » communities (in the political, economic or cultural sense). This includes most Europeans, Egyptians and Levantines amongst whom those who have to work in Omdurman or Kh. North live at Khartoum and commute daily. Omdurman, on the contrary, harbours many of the modest, less exclusive communities including Indians and Yemenis. Kh. North is unique in that its foreign community is highly specialised as to extraction—more than half are Egyptians (1.479 out of a total of 2.229 in 1956); hence the popular notion that Kh. North is an « Egyptian colony ».

An important consideration in analysing foreign communities is the question of permanence and transience. This is generally reflected in the sex-balance and the age structure. « Settled », enduring foreign communities are « family » communities, wherein the distribution of sex and age does not appreciably deviate from the native norms. Thus males and females are roughly equal, while children (—15) outnumber either adult group [1]. The Egyptians, Syrians and Indians in the capital illustrate this type. Transient communities are unstable, uprooted—in short showing a lop-sided unisexual bias to pronounced adult masculinity. Generally, but not necessarily, the « settled » communities represent a peaceful, « residential » type of colonisation, whereas the transient belong to the « exploitive » type. Most European communities in the capital approach this type.

The Egyptian community is numerically the most important in the Three Towns, being twice as many as all the Euro-American communities put together. It is, however, much less drastically concentrated in Khartoum, although the majority reside there, the balance being about equally distributed between Omdurman and Kh. North. The roots of the community in the Sudan are quite old, dating back to the conquest era, but more particularly and directly to the re-conquest. After being routed and chased out of the Sudan during the Mahdism, many of them returned in the wake of the reconquest. The majority of the Khartoum Egyptians are Copts and represent the permanent, hard core of the

(1) *Ann. Rep.*, 1955-1956.

community in the Sudan, the «family», element. They are mostly officials and civil servants, in the Sudan government, and a goodly number of them partake in the liberal professions of the capital and enjoy a high standard of life. The fact that they have successfully settled and taken permanent root in the Sudan can be read in their normal sex-ratio and age-pyramid; almost all of them live in family. Many have intermarried with Sudanese, with the important «muwallad» element as the result. The Egyptian community does not really preponderate and predominate except in Kh. North where it constitutes the sole important foreign community. Apart from this permanent sector, there is a transient Egyptian element of officials, experts and teachers—true «cultural exports» from the north.

The European communities follow in numerical strength (nearly half the Egyptian), but are tersely congregated in Khartoum practically to the exclusion of both Omdurman and Kh. North. These communities are, however, economically very influential, and still exert undue control over the business of the capital, indeed of the whole country. Contrary to expectation, the British are not the major element in this community. They do not exceed a few hundreds and have in post-independence days been fast declining. Moreover, they have always been almost exclusively a male population [1]. Apart from a modest Italian colony, the biggest European community is the Greek, including Cypriots. Their origins stem from the days of Kitchener when they made quite an influx in 1902 [2]. The dictum that «under every stone in Egypt there is a Greek» may safely be extended to the Sudan. Many of them are Khartoum-born. They total some 3.000 in the capital, mostly in Khartoum itself. Investigation and enquiry showed them to have originated primarily from the outer islands of Greece, particularly Cyprus, Mytelene, and Cephalonia —not from the mainland. Their economic role in the capital is very vital: they dominate the export-import business, wholesaling and retailing, monopolise the wine trade and many of the nascent industries. A good deal, however, are engaged in petty servicing (barbers, waiters, etc.). In general it can be said that they are in Khartoum what the French used to be in Cairo.

(1) *Ann. Rep.*, 1955-1956. (2) Walkley, 1936, p. 88.

The Asiatic communities include Indians, Levantines, Armenians and Yemenis. Numbering some 800 and playing a fundamental role in retailing, especially in Indian fabrics, the most salient feature of the distribution of the Indians is their overwhelming concentration in Omdurman, almost to the exclusion of the two other towns. This indicates a particularly narrow social, cultural and ideological distance between them and the native Sudanese. Contrariwise, the Levantines, who total some 600, mostly gather in Khartoum. They mainly immigrated in the pre- and post- world war I. years with the miscarriage and collapse of Syrian industry. The majority came originally from the bigger towns, especially Aleppo, Homs and Damascus. It is an interesting feature that they consist of congeries of related families, the success of an immigrant family bringing in more relatives from home. Many are now Khartoum-born and a good deal of intermarriage with Egyptians and Sudanese has taken place. They are given entirely to trade and particularly control the retail business in clothing, hosiery etc. Among the foreign communities of the Sudanese capital they occupy much the same role assumed by the Greeks in Egyptian towns. The Armenians (600, confined to Khartoum) monopolise certain economic lines, e.g. the photographing business. There is also a Jewish colony of heterogeneous nationalities. The Yemenis are certainly the most interesting group; monopolising grocery to a stratling degree, they are easily the counterpart of the Syrians and Palestinians in Egypt. They cluster essentially in Omdurman and form an entirely masculine community; hence perhaps their prevalent odd habit of sleeping in their shops! Unlike the Yemenis, the Abyssinians in Khartoum are to a large extent a female population—they primarily engage in the commercialised vice business.

Finally, there are the Westerners, who, if considered a foreign community, would rank foremost in number (12.000). They are the unwanted gift of «Bush Lane», that corridor of mobility which since time immemorial so repeatedly carried denizens in and out across the Sudan. «Westerners» is a summary name equivalent to the current, but inaccurate, «Fellata». It includes Nigerians, Bornus, Borgus, Fellata proper (= Fula, Fulbe),

Messellata and French Equatorial African negroes [1]. They punctuate all urban centres of the transversal « mobility belt» of the Sudan, being more numerous in the bigger towns and the capital. Until 1952 they were estimated at 4.000 [2], which, with a 1956 total of 12.000 would mean that they have doubled themselves threefold in the last few years. They are equally distributed between Khartoum and Omdurman, but almost disappear from Kh. North, presumably because their presence depends on the existence of a large body of native population. The Westerners are about the only foreign group looked upon by the natives as decidedly inferior. They represent a casual, unskilled labour pool taking up what jobs the natives may shun or disdain [3].

III. SITE, GROWTH AND PLAN.

I. Site.

Occuping a peninsular site, the Triple Capital stands at a break of gradient in the river course due to hermetic confluence. Heavy deposition of silt is the result, hence the site is studded with an unusually big number of islets. This is the same story at Cairo and Paris [4]. These islets gain in size at the low-stage and some occasionally coallesce. Tuti island is the largest and most central. Owing to the changing directions of the bending river, while the riverside at Khartoum East experiences much deposition, that of Khartoum North is one of sharp erosion. This contrast is eminently visible at the Blue Nile Bridge. On the other hand, along the White Nile Omdurman is the eroded side while the western bend of the Kh. North together with Tuti island suffer extensive deposition. Indeed, the line followed by the ferry plying between Shambat (to the north of Kh. North) and Omdurman (at Abu Ruf) and acting as the

(1) Issam Ahmad Hassoun, « Western Migration and Settlement in the Gezira», *S. N. R.*, vol. XXXIII, 1952, pp. 60-81.

(2) *Ibid.*, p. 76.

(3) *Ibid.*, p. 95.

(4) M. Clerget, *Étude de Géog. urbaine,* Cairo, 1935 and P. Lavedan, *Géog. des Villes,* Paris, 1936.

only link between the two sides of the White Nile, this line is determined by the limit free from silting. Again, while the Blue Nile front of Khartoum is generally high except at the extreme east at the Burris, the White Nile front is an exceedingly low-lying tract (—375 metres) and usually subject to flooding—occasionally to a disastrous degree as in 1946, a year of abnormally high flood. This contrast has a direct influence on urban land-use. In virtue of their disposition to the river courses, slope in the three towns is, generally speaking, gradual outwards. While this may mean exposure to sudden torrents from all sides especially on the peripheries of the built-up area, it also helps solve the problem of drainage. Omdurman, however, is luckier in that it has a higher elevation, hence a greater slope, plus two « Khors» (wadis) acting as natural drains : Abu Anga in the south and Shambat in the north. This explains why street open drains, which line most streets in Khartoum and Kh. North, are very rare in Omdurman [1]. Soil in Omdurman is lateritic ironstone, therefore very hard [2]. Good for mechanical transport, but bad enough from the viewpoint of a « green belt»; tree planting being so difficult in the gravelly soil. Hence Omdurman is deprived of trees and gardens, private or public. The few exceptions have had their soil brought up from the river alluvium [3]. This aggravates the existing appalling overcrowding, all the more so within a massive built-up perimeter under a scorching tropical sun. This is in sharp contrast to Khartoum, essentially a « garden-city» settlement. Kh. North, at the other extreme, is locally dubbed « mud-city» on account of the nature of its soil [4].

II. Growth.

The influence of the site pattern on the growth and lie of the built-up area is evident in many respects. In the first place, the nucleus of each of the three towns originated at the water-front and grew away from it;

(1) Sudan Government, Memorandum on the Layout and Development of Khartoum, Kh. North and Omdurman, July, 1933, p. 40.

(2) Id., p. 37.

(3) Id., p. 42.

(4) *Ann. Rep.*, 1955-1956.

that is the water-bound sectors are the oldest and the peripheral outskirts are generally the latest. Then there is the very salient fact that growth has been everywhere annular, with Tuti island as a hypothetical centre. This concentric accretion, however, has not proceeded symmetrically; it grew earlier and quicker in certain directions and was retarded and tedious along certain lines. The differentials of push and pull have primarily been site controls and explain any « eccentric » detail in the outer contour of the whole agglomeration. In Khartoum the growth of the eastern sector began so much earlier and went so farther than the western that it is legitimately the nucleus. This is explained by the higher contour, thus better drainage, better scenery and healthier atmosphere [1]. The floodable lowlands of Khartoum West have always militated against development [2] all the way south to the so-called Gordon Tree where land rises again to the level of the river and where, thanks to two exceptionally elevated goz loops (sand dunes), the two settlements of el-Goz and Rumeilah (the names signify the sandy structure) are quite old. Otherwise, Khartoum West has been very tardy to grow, development having begun only as late as the post-war years, and that despite the strategic position as the inevitable bottle-neck to Omdurman. Until the last war the main axis of growth for Khartoum was the east-west with the Blue Nile as a base line, and the whole body of the town was tightly hemmed in by the « rail ring », beyond which occupance was confined to extensive barracks south and east and, in the southeast, to the aerodrome and the « Old Deims »—a squalid slumdom for workers. With the war-fostered « explosive period » of growth the town found herself imprisoned within an iron curtain including the rail loop and these outlying utilities. Only were the deims demolished, and growth has since been a tremendous tidal wave southwards. So much so that the major axis of the town is now along north-south. The built-up area thus assumes the shape of a well-defined T, the angles of which are occupied by the aerodrome in the east and the wastelands in the west. In view of the great value of a water-front in a hot, dusty, haboob-stricken area, the southerly trend of growth is anything but sound planning.

(1) Memorandum etc., pp. 13-14. (2) Id., pp. 9, 12.

Growth in Omdurman has been a different story. It has not been so much an accretion as a process of replacement and filling in of interstitial gaps; Omdurman occupied a larger area during Mahdism. The slight post-war development has taken place rather equally on three sides, although the south barracks opposite Khartoum are already a serious check. The natural trend for Omdurman would seem to be southwards to Fetihab village in order to approach Khartoum. Apart from the barracks barrier, the wastelands of Khartoum West seem to have discouraged this trend.

As to Kh. North, the western old settlement of Hillet Khogali and Hillet Hamad represents the nucleus of the town whence growth proceeded eastwards along the river front thence inwardly. The rail-line, now ruthlessly bisecting the town, has long hindered growth eastwards. Here again the vast riverside barracks were a barrier to continued growth. Frustrated by these uses, growth has lately swerved to the north to Sababi and to the extreme east at Hillet Kuku—the latter a sound trend.

In general, growth in the three towns, but most particularly in Khartoum, has been at very liberal, almost prodigal, dimensions—for the whole conurbation is composed, apart from few exceptions, of strictly one-storeyed buildings. The triple metropolis is « Flattown » or « Squattown » par excellence. The reason lies in the absence of a water-borne sewerage system [1], but also in the inherent requirements of tropical, open, architecture and the imperative need for lavish gardens.

III. Plan.

Distinction must be made between two types of plan : the old, irregular, haphazard ant-hill maze common to most indigenous Levantine towns —the « archetype »; and the « neotype »—the modern, ordered orthogonal grid. The Three Towns possess both forms in varied combinations. The archetype was the original « motif » in pre-conquest days, the evils and insalubrity of which was so recurrent a theme in the description of

(1) Fawzi, *Ann. Rep.*, 1949, p. 91.

earlier voyagers [1]. Since the re-occupation, however, it has become a recessive type. In a sense, Khartoum was fortunate in that it was razed down to earth at the Mahdism, for the « second Khartoum settlement» could begin from a free, primary planning. The plan, laid out under the personal supervision of Kitchener, was a rigid échequier corrected by a network of diagonals assuming, incidentally, the shape of a series of « Union Jacks». The avowed mover behind this pattern was military control and domination through the weave of diagonals and « rond-points» [2]. The influence of a river site, however, should not be overlooked; the river-front, as at Kh. North, naturally suggested itself as a base-line for an orthogonal grid-iron. Soon, however, the many disadvantages of such a geometric pattern made themselves clear: dozens of awkwardly shaped lots at the crossroads and universal exposure to unobstructed, untamed winds, especially the notorious haboob, along the diagonals. A « thinning» process of the diagonals [3] was eventually resorted to leaving only the minimum necessary to rectify the disorientation inherent in a damier plan. Later, in the explosive period of growth, the geometric principle was strictly adhered to beyond the rail ring. It is interesting to notice that in order to avoid the transversal streets being swept by the haboob they are narrower than the longitudinal ones. The pre-urban influences are also manifest in the existing pattern; in the western sector of the « New Deims» the square pattern gives place to a triangular network based on an arterial road that was originally an old track leading from the town to the then separate villages of Goz and Rumeilah. It is also of interest to notice that both along the right and left margins, i.e., in Hai-al-Matar and in New Mogren respectively, the damier is replaced by the radio-concentric plan—obviously to counteract the increasingly excessive disorientation of the former at the peripheries.

The case of Omdurman is quite different. Despite much devastation and demolition, the result of which still persists till now, its plan is

[1] Walkley and J. W. Kenwick, « The Need for Slum Clearance in Omdurman», *S. N. R.*, Vol. XXXIV, 1953, pp. 281 ff.
[2] Walkley, 1936, p. 86.
[3] *Ibid.*

burdened by the lagacy of the past [1]. The limited modern planning that has taken place is confined mostly to the new peripheral growth. It has taken the form of « superimposed planning» by grafting a number of rectilinear arteries on the old criss-cross and the form of « complex ordinance» in the modern peripheral growth as well as in such central, newly re-planned devastated quarters as the Mulazimin Quarter. It is interesting to notice that the arterial route followed by the tram-line across the town describes an arc that is fairly parallel to the outer perimeter of the whole agglomeration.

Finally, the case of Kh. North is an amalgam of the patterns of Khartoum and Omdurman. The old westerly nucleus of Hillet Hamad and Hillet Khogali is of the archetype plan to which was appended, with a minimum of interdigitation, an extensive neotype domain in the east.

IV. FUNCTIONAL STRUCTURE IN THE THREE TOWNS.

1. On the dynamic side, early data, though scanty, are enough to detect the basic lines of development. The most salient feature is no doubt the persistence through the decades of certain fundamental lineaments in the functional structure. Thus in Khartoum the Blue Nile front has stubbornly been monopolised by the administrative use, with a few enclaves of high class residence. On the other hand, Khartoum on the White Nile and its southern approaches has invariably been the ugliest and most bleak section [2]. Again, the commercial core, the central business district (C. B. D.) shows a remarkable fixity around the central mosque and its environs. Similarly in Omdurman, the commercial —and—administrative nucleus remains today exactly where it figured in the earlier maps such as that of 1906—a constellation of buildings of administration, police quarters, prison etc. From as early a date as our map goes back, residential segmentation on a basis of cultural segregation is a prominent fact. There was thus a separate quarter for the Arabs (Arab Quarter), another for the Copts [3]. In general, the historical

[1] Kenwick, pp. 281-283.
[2] Walkley, 1936, p. 73.
[3] 1906 Map, Survey Dept., Sudan Govt.

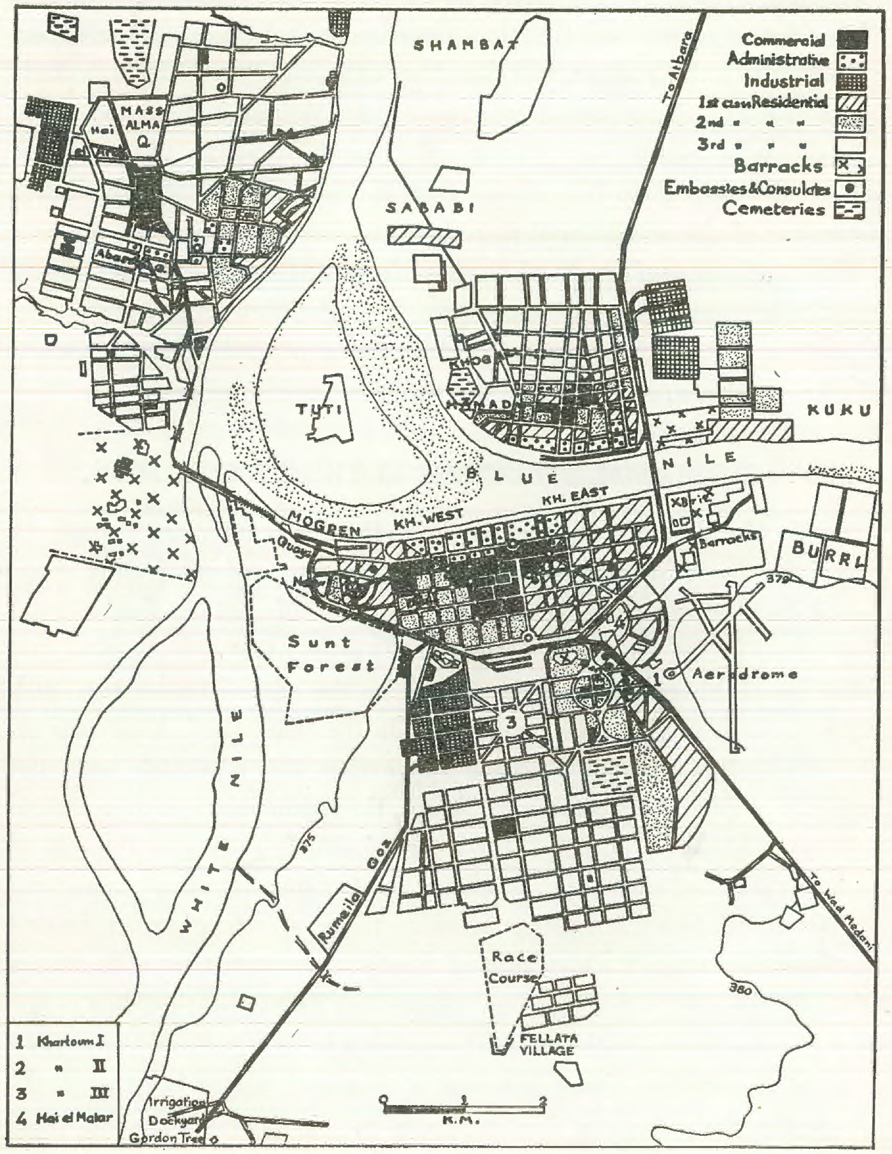

Fig. 1. Functional structure of the Three Towns.

sequence amply shows that the growth and expansion of the Three Towns especially during the explosive period have been accompanied by potent ecological centrifugal and centripetal processes and a concomitant internal re-arrangement and re-distribution of urban uses. In the face of the surging wave of expansion, many functions which had been logically sited soon became anachronisms and misfits; they had to be re-sited in accordance with the novel frame-work. Outstanding such cases are the demolition of the Old Deims and the development of the New Deims in Khartoum and the re-siting of the artisan industries from the hearts of Khartoum and Omdurman away in a peripheral sector. Gross, lagging incongruities are the various cemeteries of Khartoum which still remain notoriously embedded into the residential area, while the abandoned barracks and the aerodrome represent a serious handicap to town growth and planning.

2. At present, the Three Towns can be said to be fairly mature as regards functional differentiation. This has been forced by strict «zoning» ordinances and a town planning body. Thus in all three towns commerce displays a remarkable degree of centrality in a core where all commercial activity is tersely and ruthlessly concentrated. Apart from areas of third-class residence, «neighbourhood shops» are therefore entirely lacking. Their presence in the poorer areas is necessitated by their inhabitants' inability to undertake the long daily shopping journey to the C. B. D. or to keep sufficient household stock. In any case the excessive concentration of commerce in a hot, sun-baked town is a real inconvenience to all classes alike—a fact reflected in complaints and petitions for permits of neighbourhood shops. Instead of complete decentralisation, the spectacular growth of the towns has engendered a process of hiving-off from C. B. D. to neighbourhood centres—subcentralisation. Such for instance is the story of the Saggana market which by ordinance was moved from the Arab market. So it is with the newly erected subcentres in the newly developed margins. In Omdurman, besides the main central buisiness district, we have quite a number of local submarkets, the Murada market, Banat, Beit el-Mal and Abu Ruf markets etc. In view of a still limited perimeter no such fissioning at the C. B. D. has taken place at Kh. North yet. A very suggestive characteristic of the C. B. D. in the

Three Towns is the dual market system—the co-existence of a native, « Arab » market and an « European », modern market. This is not quite unique or individual to the Three Towns but common to most towns of cross-culture, e.g., Middle East towns [1], Durban [2], etc... In the case of the Three Towns each market tends to be located on the side of its respective residential quarter, with the central transport station separating and sandwiched in between. Within each market functional differentiation to an amazing degree is the rule. By zoning, every trade and line of business has its compact, definite area. Strategic locations are given certain key trades.

The administrative function occupies a location midway between centrality and marginality, but always in a compact, well-defined kernel. It is naturally most extensive in Khartoum where it occupies the Blue Nile frontage almost in its entirety. The same is nearly duplicated at Kh. North. It is only in Omdurman, however, that the administrative kernel regresses away from the river to a definitely central location. In all three cases, however, the area abuts on the C. B. D. on one side or another. The monopoly of the water-front by administration is an old-standing, almost endemic, characteristic [3]. It is now urged that, in Khartoum and Kh. North but more specifically in the former, this is hardly the optimum use for such a location : residence might well be a better use.

Such functions as education and religion reveal a fairly harmonious correlated localisation. Apart from a bunch of central bodies of each near the town centre such as the congeries of foreign missionary schools and churches south of the Arab market in Khartoum, they tend to be scattered within the residential areas according to class, religion, minority and ethnic group. Once peripheral, the more centralised of these utilities are already ill-sited with respect to its juvenile clientèle which undergoes an extensive daily journey.

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[1] Dalton Potter, *The Bazaar Merchant, in Social Forces in the Middle East,* ed., S. N. Fisher, N. Y., 1955, pp. 103-106.

[2] H. C. Brookfield and M. A. Tatham, « Distribution of Racial Groups in Durban », *Geog. Rev.,* Vol. XLVII, No. 1, Jan. 1957, p. 64.

[3] Walkley, 1936, pp. 86 ff.

Fig. 2. Functional Structure, Omdurman.

The story of the industrial function is quite instructive. It was initially hoarded in the very town centre, the Arab market, where it competed with commerce and transport for space—a common medieval feature in Eastern as well as Western town-life. Under the push of the centrifugal tendencies all handicraft artisans and native workshops have, by zoning, been re-sited in some convenient peripheral location, while the establishment of modern industrial plants has been strictly zoned in similar areas. Thus in Khartoum the old industries have already been moved to the new « light industrial area » where such post-war introductions as car and lorry repairing, the town petroleum installations and depots, the power station, public works and mechanical transport factories and yards, etc. are localised. In Omdurman the process of re-siting is not over yet. In all three cases the well-defined as well as discrete industrial area is decidedly peripheral in position, in the west in Khartoum and Omdurman and in the north east in Kh. North. The positioning in the first case is particularly sound; it occupies the floodable lowland wastes which have for long been shunned by residence, lies close by to the central railway station and is in close proximity to the New Deims—the main labour reservoir of the town.

Considering finally the pattern of residence we find that class segregation is a strict phenomenon, so much so that first-class residence never abuts on third-class areas : a zone of second-class housing must interpose. The most significant geographical feature, however, is the class-area arrangement with reference to the water-front : invariably in all three towns the river-side residence is first-class. It may be north or south, east or west in each town, but always river-bound. Residence steadily declines to second then third-class as one moves away from the river. Such exceptions as internally situated high-class residence in Khartoum I. is explained by the unavailability of further room along the river. With Tuti island as a point of reference, the general pattern is a concentric social hierarchy of urban habitation. The magnetism of water to best-class residence in a tropical agglomeration is overwhelming; social class varies directly as proximity to the river front, even when this occasionally means that it varies inversely as contour. Although the influence of high contour is amply shown in the case of Khartoum East [1], that of the water front seems to be generally prepotent [2]. This is partially contrary to the physical control generally experienced in western, river-bound cities where the upper and lower parts are often socially upper and lower class as well, and where riverside flats and shallows are workers' residence while the higher slopes are sought by the rich [3]. The reason for this reversal is to be found in climate. Thus while in lower latitudes in tropical Khartoum (as well as in Egyptian towns for example), the refreshing, pleasant water-front becomes a magnet for upper classes, a true « Gold Coast », to use the phraseology of Zorbaugh ; in cold latitudes, on the contrary, it becomes the « trap » of fog, smoke and chill, thus shunned by the rich and left over to the economically hard-up classes. This neat distributional ordering of social class subsumes further aspects of « social topography » [4]. Thus the vast majority of Europeans and foreigners are confined to the first and second class areas, according to economic status. Khartoum East confessedly began as the « European Town » [5]... They are further segregated according to nationality : there is a fairly well-defined « Little Greece », a « Syrian Town », while most British clustered mainly in Khartoum East near the river front. Much concentration is shown by the Egyptian community and their establishments in Khartoum West—the Mogren. It must be clear what all this social-residential gradient from riverside to periphery means. It means a decreasing minimum plot area in housing, that is an increasing density of population as well as of building. Thus by zoning ordinance, density of building is fixed at 3-8 houses to the acre for the first-class areas, can rise to 10 in the second, and so on. There is thus a progressive decline of the ratio of garden to building and void to solid, a lowering of standard and material of building, sanitation (type of sewage)—even colouring of building! etc.

(1) Memorandum, pp. 12-13.
(2) Cf. *European residence in Durban,* Brookfield and Tatham, p. 59.
(3) A. E. Smailes, *Geog. of Towns,* London, 1953, p. 90.
(4) Gaston Bardet, *L'Urbanisme,* Collection Que sais-je?, Paris, 1947, p. 56 ff.
(5) Memorandum, pp. 12-13.

V. OMDURMAN : A SYNTHETIC STUDY.

To conclude this systematic treatment of the urban geography of the Three Towns, we may attempt a synthetic sample, Omdurman, an interesting specimen of a tropical, African town. Of the Three Towns, Khartoum alone is functionally and structurally the « mature town », in the sense that it reveals a full measure of functional differentiation, hardly dissimilar from that revealed by studies of other European or American cities. Thus we squarely encounter the fundamentals of the Burgess concentric hypothesis—only, as in the case of Chicago, in a semi-circle as a result of the presence of the Blue Nile water front. While in Khartoum a full tripartite differentiation is strikingly evident, distinction in Omdurman is restricted to a core-integument dichotomy. It would be far-fetched to recognise an interstitial inner « zone of deterioration » despite the massive body of the settlement. The arrested growth of the town no doubt accounts for that; not only has it been characterised by replacement rather than by accretion, but even was it once of greater extension than it now is [1]. Besides, such forces, factors and ecological processes (as the journey-to-work, a highly developed transportation and a high standard of living) that normally control the urban pattern of a modern town, are not fully developed in Omdurman. Rather, part of the daily relations of the inhabitants are connected with Khartoum, not with the town centre itself. If it be recalled that, during the Revolt, the Mahdi and his successor built the central administrative bodies at the town centre then surrounded them with their own and their entourage's residences [1] it will be noticed that such was the medieval urban pattern in Europe as well as in the Orient where the ruler lived in the centre, the higher classes immediately around, followed outwards by the populace. The town centre and its immediate environs are still the favourite residence of many notables while most doctor's clinics and lawyers offices cluster there. One is justified to hazard

[1] Memorandum, p. 37.

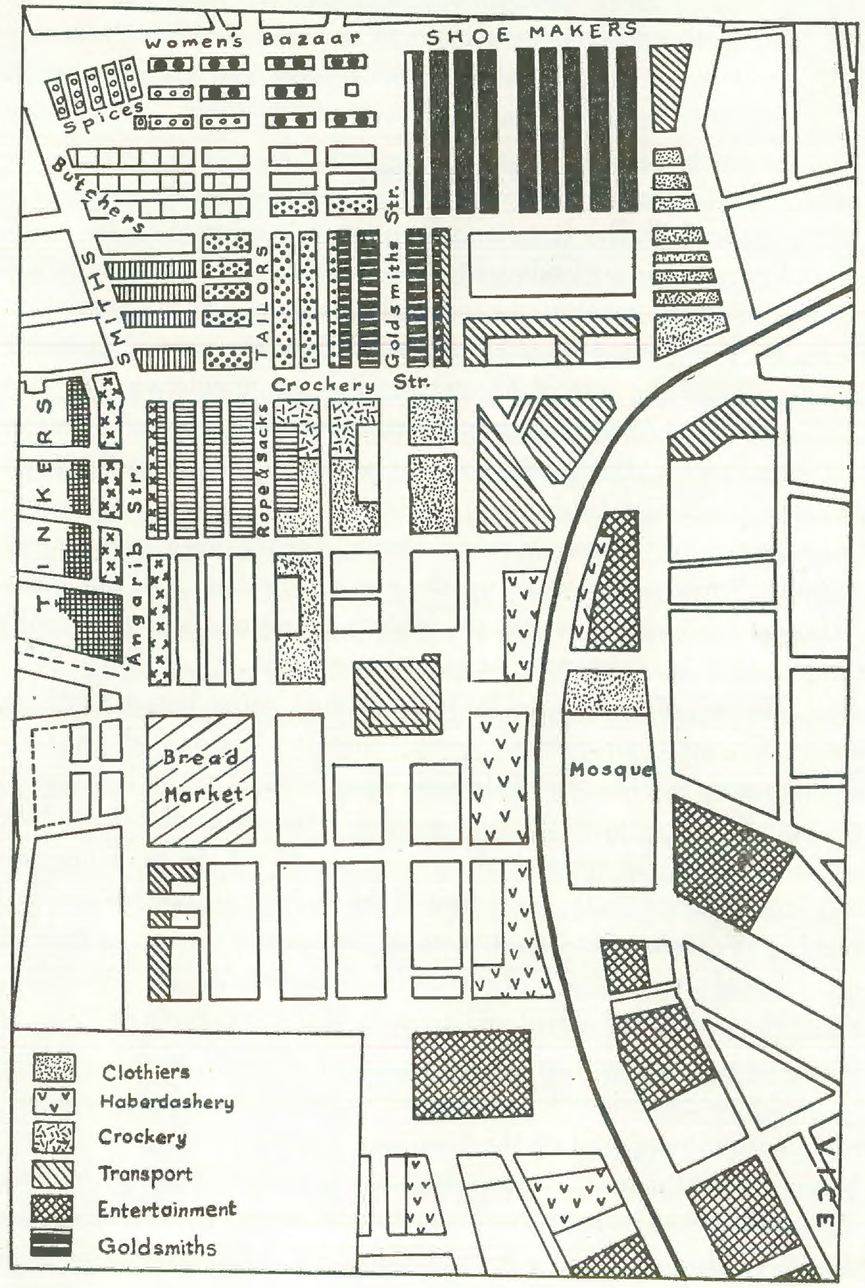

Fig. 3. Main business groupings, the Suk, Omdurman.

that, in terms of urban maturity and internal differentiation, Omdurman is something like a century behind Khartoum. Accordingly we may divide Omdurman into 2 urban regions, the core and the integument.

I. The Core.

This is the C. B. D. It extends from the native bazaar in the north to local government and administrative centre in the south, assuming an elliptical shape roughly situated in the centre of the agglomeration. One notes the internal situation as distinct from the riverside position characteristic of the core of Khartoum. Political orientation underlies this contrast : while at Khartoum it was the western ideals of urbanism that were at work, the Mahdists sought protection away from the river. Being so pivotal in Omdurman, the core is the hub of the central transportation of the town to which lead all the few main macadamised arteries. Three sectors make up the core : The Suk, i.e. the native «African» bazaar in the north, the modern service centre in the middle and the local administrative segment in the south.

(a) *The Suk*. This is by and large the greatest native bazaar in Africa, indeed a unique phenomenon symbolising the commercial greatness of Omdurman and worthy of detailed analysis [1]. The nuclear core of the town, it still occupies the same position it had under Mahdism. Here are crammed all the commercial services not only of the town but of a vast hinterland especially in the west of the Sudan. Its commodities and supplies are drawn from most parts of the country as well as from all countries of importation. Four main characteristics are observable. First, the survival of a medieval tinge in that it combines industry to commerce : many shops in the shoes, dates, butchers, smiths, tinkers, 'angarib (native bedsteads) blocks and in the «women's bazaar», still manufacture their goods on the premises. Modern planning has already begun moving the heavier industries, such as grain milling and tanning, to the newly zoned «industrial area» outside the core. The Suk is then characterised by exclusive, minute specialisation, a feature common to all

[1] The following analysis is the result of an intensive personal field survey.

oriental bazaars. On a grid pattern, every trade or industry is allocated a special block. Street specialisation revealed by street names is also typical; witness Silversmiths' Street, Porcelaine Street, etc... Each trade draws its materials from convenient sources : for 'angaribs wood from Mashra'a Abu Ruf, palm leaves from Northern Province and rope from Abu Ruf and Murada. Crockery from abroad via Port Sudan, jute and cotton cloth and clothes from India, textiles from Egypt and Europe contrast with meat, hides and live-stock which come from the west country, from Obeid and Fasher. A good many Indian merchants participate in the clothing trade, while the «womens' bazaar», so-called, is entirely a feminine affair and engages in knit-wear and haberdashery—all made on the spot. It is interesting to notice the areal correlation between blocks of cognate functions. Thus in the extreme north east of the Suk stands the hides market, therefore in the most convenient position to receive the raw material from Tanners' Quarter at the north-easternmost part of the town along the river and north of Abu Ruf. Immediately west of the hides market is found the shoe-makers' block. In the north-western section of the Suk the Wadak (native ornamental grease) block is contiguous to the butchers quarters whence the requisite fat comes. In the west, blacksmiths, tinkers and 'angarib makers are all juxtaposed. In the southwest the bread and grain markets hang together, while by the car parks area and bus station are located all spare-parts shops and mechanical engineering business. It can be seen that the areal allocation of the different functions is highly logical : the forefront of the Suk where terminates the trunk route from Khartoum, that is the eastern sector in general, monopolises the lighter, more modern, less «native» and more retail-like lines of business which command a high overturn. These include transport (the central stations), novelties, banks, ready-to-wear clothes, chemists, physicians, cafés, clubs, bars and groceries. In all of them the foreign element in personnel, including Egyptians, Indians, Yemenis, Greeks and Jews, is paramount. On the other hand, bulky commodities and heavier, less modern, rather wholesale types of trades are relegated to the backs of the Suk. Amongst these may be mentioned the butchers, smiths, tinkers, herbalists, sacks, spices and grain dealers.

(b) The rest of the town core is made up of the centralised servicing area and the local government area. The former is the southerly extension of the Suk but comprises congeries of public utilities and central services such as extensive hospitals, private clinics, lawyers, and a great number of varied schools—commercial, nurses' and girls schools etc. The majority of these institutions are closely linked in function to the Suk. An unusually rigidly concentrated vice belt lies in Hospitals Street. South of this service area extends the administrative and local government enclave comprising the Mudiriya (governorate), police head-quarters, the municipality and the town prison.

II. The integument.

Apart from the core, the rest of Omdurman is a vast, almost undifferentiated body. Despite certain morphological and demographic features such as the existence of some brick houses and some foreign communities like the Armenians, there can be no question of an inner zone of deteriotation. Apart from two limited segments—the Mulazimin Quarter (al Sur) on the Nile on the east and the Industrial Area in the west, the integumental area is a fairly homogeneous sea of poor residence. It will be noticed that the two last mentioned sectors lie along a transversal line with the C. B. D., thus forming a radius bisecting the town. The high class residential quarter is an example of a strong tendency to persistence in urban use : it was the favourite residence of the leadership of the Mahdism as is still revealed in the name Mulazimin (retainers, retinue). Significantly, it was a walled enclave, the remnants of the wall being still visible—hence the alternative name el-Sur. The quarter was thoroughly ruined during the re-conquest and until very recently remained a vast morass of holes and hollows shaped as a crescent—the « empty quarter » of Omdurman ! It has lately been re-planned along a geometric pattern and in liberal plots to be the villadom of the depressed, bleak town. While still underdeveloped, many luxury tropical villas, occasionally two-storeyed, and vying with the best in Khartoum, have appeared, with occupants including many of the foreigners working at

Omdurman. Turning to the « light industrial area » we find that many of the industries previously located in the C. B. D. in the medieval, native tradition, have been moved into this newly, geometrically-laid out sector. Herein geographical division of labour is based on specialisation, with each trade in a specific block. The leading industries are flour-milling, dying, oil-seed pressing, an ice and soft drinks factory. A « noxious trades » area is thoroughly isolated while the industrial area as a whole is well kept apart from residence.

As to the poor residential mass which lumps up the greater part of the agglomeration, here we encounter a highly undifferentiated body of homogeneous cells—pygmy (universally one-storeyed) mud houses, stereotyped blocks, each highly reminiscent of Egyptian 'ezbas. Overcrowding is appalling : Kenwick found in a sample study of 259 plots in al-Murada a number of 2273 inhabitants at a density of 3.25 persons per 100 square metres [1]. Streets are narrow and unpaved, but the mass is occasionally traversed by some main roads along which straggle extensive lines of neighbourhood shops. It is also dotted at convenient intervals by foci of neighbourhood (hara) markets such as the Shagara, Murada, Beit el-Mal, Abu-Ruf, Banat, etc. While essentially a matrix of poor-class residence, it is nevertheless occasionally punctuated with the homes of notables and high officials who take great pride in such significantly native habitat. Apart from the unduly reigning morphological monotony, the ethnic segregation stemming from the days of Mahdism, is the salient feature. Thus north of the Suk we find the Massalma quarter which, in spite of the name, is the Copts' area. The anachronistic misnomer is explained by the fact that while originally a Christian area converted to Islam during Mahdism (= Massalma), a pocket has remained unconverted, but is included in the areal designation. West of Massalma quarter is the Hai al-Arab (the Arab quarter), so called because it has been since Mahdism the rallying point of the Arab elements from the north of the Sudan. The Abbassiya quarter, south of the Suk, is known

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(1) *Op. cit.*

to harbour the bulk of the Omdurman Fellata. Finally one may notice along the outskirts of the town many naturally peripheral utilities and institutions such as the tanneries on the river water in the north, the wireless stations and broadcasting house in the west and finally the barracks in the south.

Photo 1. Old Mogren, Police «Harimat» Lines, right and Egyptian teachers blocks left.

Photo 2. New Mogren : «villadom» and «garden city».

Photo 3. Fellata Village. Khartoum.

Photo 4. Khor Abri Anga, Omdurman, in dry season.

SOME ASPECTS OF MIGRATION IN CAIRO

BY

M. S. ABOU EL-EZZ

Migration is neither a simple nor an easily analysable process, especially when particular statistical difficulties are encountered when trying to define the extent and prevalence of such a process. The object of this paper therefore, is to ascertain the facts about the phenomenal interchange of population between Cairo and the other provinces and governorates of Egypt, through surmounting some of the statistical obstacles, and by formulating convenient migration rates. The subject matter of this paper will be tackled from three angles namely : I) Population growth in Cairo. II) In-migration and out-migration. III) Population movement within the city.

I

Cairo owes its importance to its population and its prosperity, to its antiquity and its historical reputation, and therefore it rightly deserves to be called the historical Capital of Egypt. With the centralization of authority and administration; Cairo is also the political Capital. It is also the economic Capital of Egypt since it serves as intermediary between the production of the country and its demands from abroad [1]. No wonder then that its population has grown rapidly throughout the last five decades, for it has acquired through its functions a centripetal force which attracts the inhabitants of other parts of the country.

Population data relevant to Cairo will be studied for convenience only in the first half of the present century, since pre—census sources—such as the occasional individual estimates similar to those carried out

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[1] R. E. DICKINSON, « City region and regionalism», London, 3rd Ed., 1956, pp. 12-13.

by Amici (1877)[1], give nothing but vague and generalized results. In 1882, the first population census was taken, but the disturbed condition of Egypt at the time, reduces its validity as a reliable source. It is thus inevitable to derive our information only from those national censuses which were held once every ten years from 1897-1947[2].

When trends in population growth are being considered, it is necessary to check any changes which may have taken place in the boundaries of enumeration units between censuses, since both population totals and administrative areas have to be related[3]. Consequently, the numbers of population in the different districts of Cairo must be adjusted in the 1947 census for earlier years. This was accurately carried out by a thorough process of elimination and addition.

The following table gives the general trend in population growth, and the annual rate of intercensal increase in Cairo throughout the first half of the 20th Century.

TABLE 1

Year	Population	Intercensal amount	increase % per annum
1897	598,572	....	
1907	678,423	79,851	1.5
1917	790.939	112.516	1.7
1927	1.064.567	273.628	3.5
1937	1.312.096	247.529	2.3
1947	2.090.654	778.558	5.9

It is evident from the above table that the growth of population in Cairo does not take the form of a steady, long-continued increase. Instead, it exhibits an accelerated rate from 1897 (1.5 per annum) to 1927

(1) F. AMICI, « Essai de statistique générale de l'Egypte », Le Caire, 1877-1878.

(2) It has been most unfortunate to postpone the carrying out of the expected 1957 census; this will disturb the sequence of the decennial enumerations.

(3) The boundaries of enumeration units in this paper are the fiscal boundaries.

(3.5) whence it attained a peak, and then the rate decelerated in 1937 to 2.3 %. This remarkable contraction of the annual rate of increase may be attributed to some factors which were the outcome of the world depression period in the thirties. The economic depression has decisively checked the cityward trek. Thus, considerable numbers of the city's inhabitants prefered to forsake its crowded insecurity for the relative security of the country. The same feature was also noticeable in Alexandria.

As regards the second peak (5.9) which was attained in 1947, special mention should be made here to the fact that the census of 1947 is considered by all authorities as an over-estimate. The accuracy of such a high rate as 5.9 % per annum for Cairo, is very much doubted especially when a rate of 2.0 % increase per annum for the whole country in the decade between 1937-47 may be regarded as beyond the productive power of the Egyptian nation. This is, in point of fact, ascribed to the tendency of the citizens to exaggerate when notifying the number of persons in their families when their ration cards were issued during the 2nd world war, and their persistence on registering the same number when the census was held on the 27th March 1947.

It is evident therefore from analysing the dynamics of population growth in Cairo, that it has fluctuated from one decade to another, but has taken a positive trend. In the decade between 1937-47, the annual rate of increase for Cairo was approximately three times that of Egypt as a whole. Meanwhile, estimates have revealed an average rate of 2.5 % in 1951-52-53-54. Assuming the present rate persists, the absolute increase of population in Cairo will mount to over half a million between 1947-57, as compared with 2/3 of a million in the preceding decade.

Cairo consists of 14 districts, the locations of which are given in Fig. (1) according to the censal boundaries of 1947. Table (2) readily shows that throughout the period between 1897-1947, there has been a universal increase in all the districts of Cairo, though the amount varies enormously from one district to another.

1. Districts with 50 to 150 % increase of the total population of 1897. These include the five districts of Azbakiya, Gammaliya, Khalifa, Darb

TABLE 2

Growth of population in different districts (1897-1947)

	Population		Amount of increase	% of increase
	1897	1947		
Azbakiya	29.873	75.422	43.549	146
Gammaliya	57.897	107.602	49.805	116
Khalifa.........	50.538	122.194	71.656	142
Darb el-Ahmar..	68.592	122.080	53.488	78
Mosqui.......	23.238	35.963	12.725	55
Bab el-Shaariya.	51.600	132.824	81.224	157
Bulaq..........	91.862	232.423	140.561	153
Abdine.........	52.981	159.300	106.319	201
Sayyeda Zeinab.	53.611	192.705	139.094	259
Wayli..........	35.469	207.380	171.911	485
Misr el-Qadima.	32.995	116.843	83.848	254
Rod el-Farag ...	15.361	192.906	177.545	1.156
Shubra.......	17.418	227.003	209.585	1.203
Misr el-Gedida..	8.138	164.919	156.781	1.927
Cairo	589.572	2.090.654	1.501.082	272

el-Ahmer and Mosqui; all five of them constitute what may be termed « *Old Cairo* » or presumably the old central zone of the city. Mosqui for instance is still its old central business district, thus having the characteristics and functions of such districts.

2. Districts with 151 to 250 % increase of the total population of 1897. These include Bab el-Shaariya, Bulaq and Abdine which form parts of the zone of deterioration that normally surrounds the city centre. Despite their unplanned and congested housing conditions, the last two districts—according to the enumeration boundaries of 1947—include newly built up residential areas such as Madinet el-Awqaf and Dokki. The presence of such areas account for the higher amount of increase recorded in the above mentioned districts.

3. Districts with an amount of increase exceeding 450 %. These include the six districts : Wayli, Rod el-Farag, Shubra, Misr el-Gedida in the north and Misr el-Qadima in the south.

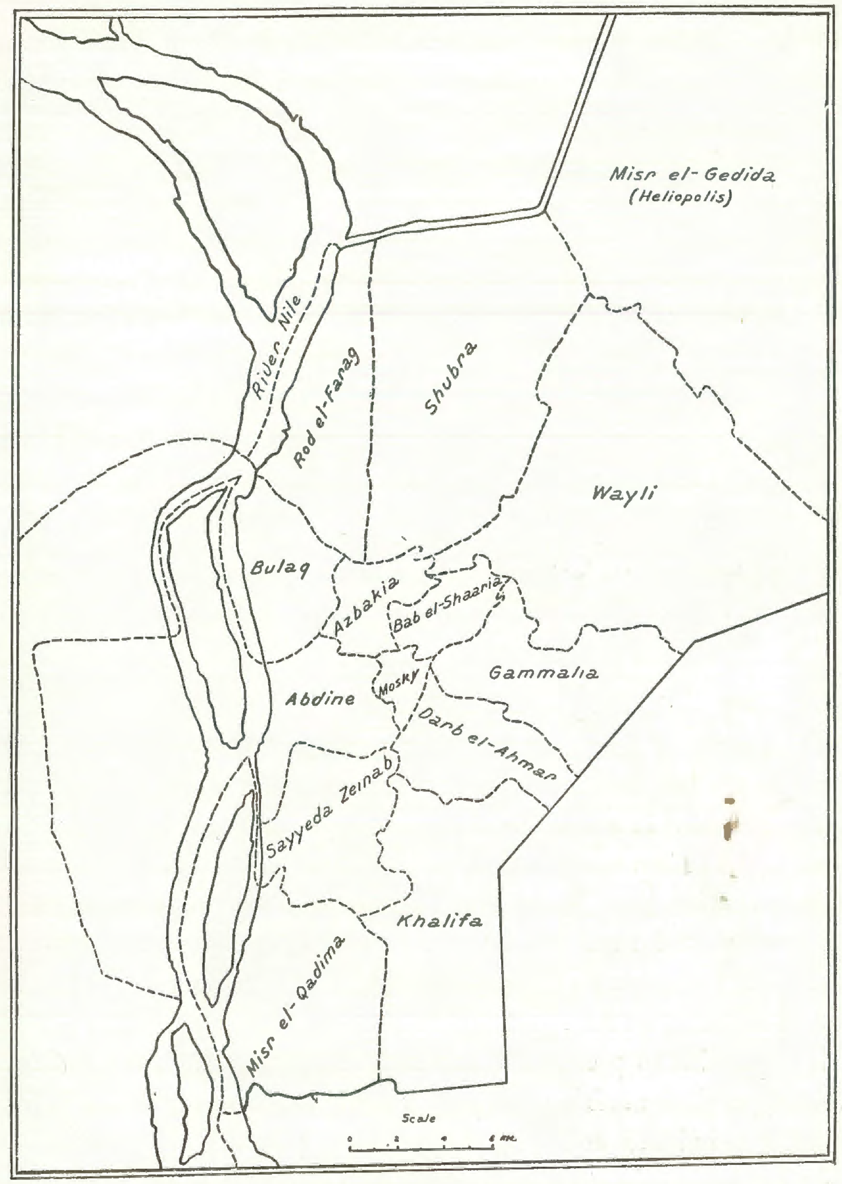

FIG. 1. Names of Cairo Districts (according to the fiscal boundaries of 1947).

5. To sum up the conclusions which could be derived from the above table :

I) A population increase was recorded in the Northern districts from 1907 up to 1947, whilst the Southward increase was recorded for the first time in 1927.

II) In 1937, a decrease was recorded in the central districts, with a simultaneous increase which persisted in the North, South and West.

III) In 1947 a suburbanward movement was recorded and directed towards the peripheral areas of the City. To the West movement is directed towards Madinet el-Awqaf and to the South towards Maadi and Helwan (this movement will definitely be enhanced after the electrification of the railway connecting Cairo with Helwan). To the North population movement is directed towards Rod el-Farag, Shubra and Misr el-Gedida, and to the East towards the Moqattam block which bounds the city on that direction.

It is possible to conclude here that population growth in Cairo, coincides closely with their movement from the old central districts to the outskirts.

II

The growth of Cairo—as has been mentioned above has been quite rapid in the last five decades,—and migration has played a major part in that growth. It is doubtful if there is any country in the world where there has not been some rural-urban migration and a remarkable growth of urbanization since World War II. Rural-urban migration is one of the most powerful and consistent forces in Egypt, and everywhere its centripetal foci are the « *Chefs Lieux* » and particularly Cairo ; the greatest Metropolitan settlement.

It is possible to process the true facts about migration into and from Cairo through scrutinizing that part of the census which gives the distribution of population according to their birth place.

As far as in-migration is concerned, its volume could possibly be clarified by computing the number of « outsiders » in Cairo. Out-migration meanwhile could also be defined by studying separately the rate of in-migration into the eighteen provinces of Egypt, and computing the number

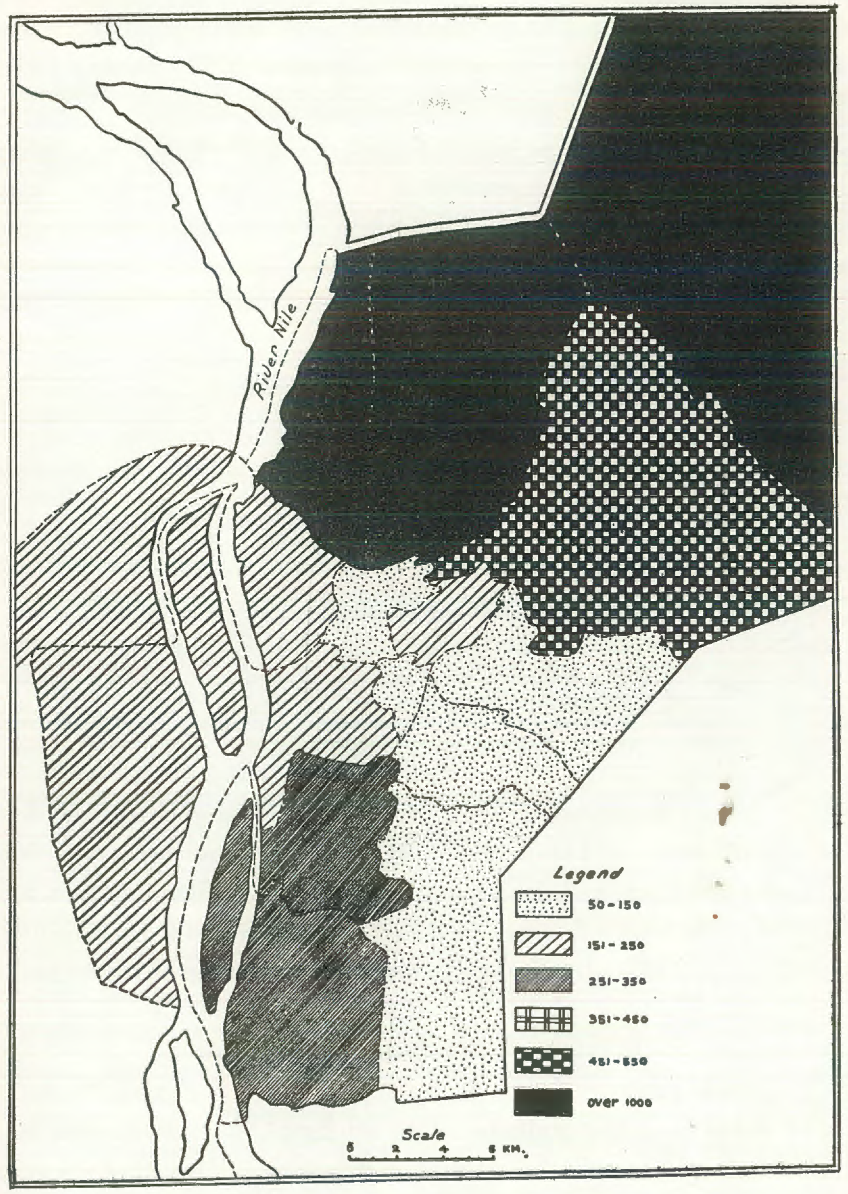

Fig. 2. Percentages of Population increase in the different districts of Cairo from 1897-1947.

of «Cairoits» enumerated in each of them. Such net figures however, may fail to indicate some of the significant short term drifts, thus creating a discrepancy between place of birth and place of enumeration. Some of this short-range movement was not migration at all; because either the place of birth or the place of enumeration was accidental; but some of it was genuine migration and has a pattern of its own. It is difficult, therefore, to separate the accidental from the true migration, thus adding to other statistical difficulties which are often encountered when analysing migration.

TABLE 3

The number of in-migrants and out-migrants in Cairo
in 1917-1927-1937 and 1947

Date of Census	Total population of Cairo	In-migrants	Out-migrants	Net gain	%
1917.....	790.939	230.791	71.756	159.035	20
1927.....	1.064.567	368.691	65.701	302.990	28.4
1937.....	1.312.096	417.794	73.183	344.611	26.2
1947.....	2.090.654	693.807	93.349	600.428	28.3

The above table shows clearly that the intercensal gain of Cairo from the interchanges of population with the other provinces rose from 159,032 (20 % of the total population) in 1917 to 600,428 (28.3 %) in 1947. The total inflow was 693,807 in 1947 whilst the total outflow was 93,349. The contraction of the decennial percentage of net migration in 1937 is attributed—as has been stated above—to circumstances which accompanied the world depression period in the thirties.

Both table (4) and figure 3 portray the fact that while Cairo in 1947 drew from and contributed to all Egypt, its interchanges were particularly great with the surrounding provinces Qaliubiya, Minufia, Sharqia and Geiza. It is but natural that all four provinces should attract a considerable number of «Cairoits» as well as add to the growth of population in the Metropolis itself, by virtue of their geographical

TABLE 4

Interchange of population between Cairo and other Provinces of Egypt

Province	1937		Net gain or loss	1947		Net gain or loss
	In-mig.	Out-mig.		In-mig.	Out-mig.	
Governorates :						
Alexandria ..	29.856	16.445	13.411	36.511	15.368	21.143
Canal	3.090	3.882	-0.792	6.242	5.812	0.430
Suez	1.249	1.711	-0.462	3.040	4.056	-1.016
Damietta	3.629	0.380	3.249	5.419	0.535	4.884
Lower Egypt :						
Behera	10.573	3.072	7.501	18.451	3.291	5.160
Qaliubia	34.094	4.788	29.306	61.668	7.068	54.600
Gharbia.....	28.732	6.670	22.062	77.613	7.048	70.565
Minufia......	70.505	2.201	68.304	149.723	2.956	146.767
Daqahlia	21.161	3.332	17.929	42.467	3.338	39.129
Sharqia	26.463	4.208	22.255	45.069	6.118	38.951
Upper Egypt :						
Geiza	41.777	11.211	30.566	48.794	23.139	25.655
Beni Suef....	10.884	2.664	8.220	12.836	2.648	10.188
Fayyum	7.843	1.918	5.925	11.511	2.132	9.379
Minya.......	12.861	3.061	9.800	16.391	3.168	13.223
Asiut........	48.603	3.060	45.443	65.501	2.622	62.879
Sohag	30.461	1.554	28.907	42.543	1.366	41.177
Qena........	15.830	1.559	14.271	22.901	1.709	21.192
Aswan.......	20.283	1.467	18.816	27.127	1.005	26.122
Total........	417.794	73.183	344.611	693.807	93.349	600.428

proximity to it. The greatest influx however, occurs from the adjacent Minufia province which contributes 149,723 or 21.5 % approximately of the total number of in-migrants. The percentage of migrants drawn into Cairo from the three provinces of Minufia, Qaliubia and Geiza is 37.5 %.

It is also noticeable that the whole of lower Egypt—with the exclusion of Alexandria [1]—contributes 67.2 % of the total migrants, or more than double the percentage for Upper Egypt (32.8 %). Both distance and geographical location are important factors which may possibly account for this difference. Located near the apex of the Nile Delta, Cairo is

[1] Which contributes 5.1 % of the total number of migrants in Cairo.

1. The three provinces of Minufia, Qaliubia and Geiza have population densities exceeding 3,000 inhabitants per 1000 feddans. No wonder then that all three of them lose a considerable proportion of their inhabitants to the nearly Metropolis.

2. The three provinces of Asiut, Sohag, and Qena in Upper Egypt also have high population densities (3,253-4,079 and 3,162 per 1000 feddans respectively). The high population densities recorded in them are ascribed to the fact that the basin system of irrigation is still practised over considerable tracts of their arable lands. The seasonal nature of work in such basin tracts, together with the low standard of living and the insufficiency of the agricultural produce are amongst the main factors of out-migration. To the out-migrants from these provinces, more alluring and profitable means of subsistence [1] are found in the cities and particularily in Cairo. This accounts for the high percentage of migrants drawn into Cairo from these provinces (18.7 % of the total number of in-migrants).

3. Aswan province claims a unique situation if compared with other provinces. This is mainly on the grounds of : its southernmost setting, the enroachment of the desert on its narrow cultivable tracts, the relatively high level of the cultivated fringes on both sides of the Nile with the consequent lack of water supply especially during the low-Nile stage, and finally the submergence of all the lands above the town of Aswan after the construction and heightening of Aswan Dam. All these factors combined made out of Aswan Province one of the most inhospitable habitats in Egypt, with the resultant loss of a considerable percentage of its male population through out-migration. Cairo attracts therefore a considerable number of «Aswanians» which amounted in 1947 to more than 27,000 or 3 % of the total number of migrants in Cairo [2].

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[1] A considerable proportion of those out-migrants are engaged in the building industry at the bottom of the scale as manual labourers.

[2] Despite the limitations of its agricultural setting, Aswan Province attains a high population density. This could be ascribed to the fact that although the bulk of its population is classified as rural, yet about 50 °/。 of its inhabitants depend on other outside sources for their livelihood.

In this connection, it is worthwhile mentioning that Gini [1] (the Italian Demographer) stated that « ..... many think erroneously that strong currents of emigration are a sign that the desirable density of an area has been exceeded.... but the fact that many migrate from a specific area means nothing more than that many of them promise themselves more favourable conditions or a pleasanter life in other localities». This is in fact the chief motive for out-migration in addition to other geographical factors such as the depletion of land productivity and other limitations of the environment. Underlying all these factors however, is the natural increase, for in Egypt and elsewhere rural areas are more fertile than urbanities and over-population in the country always makes the cityward trek imperative. The Egyptian Vital Statistics however, show the reverse. This is attributed to the inadequacy of birth registeration in rural areas.

As regards the situation of out-migrants from Cairo, table (4) reveals the following :

1. Lower Egypt attracts 59 % of the total number of «Cairoits» who reside outside Cairo, as compared with 41 % in Upper Egypt. Presumably, the majority of the out-migrants from Cairo, represent administrative, technical and commercial individuals. It is noticeable however, that their numbers in their new residences depend on a complexity of factors namely: distance from Cairo, living conditions outside the Metropolis itself, and the attitude of the provincial population towards them. Thus Damietta whose economy lies hundred per cent in the hands of its inhabitants attracts only 0.5 % of the total number of out-migrants, and the remoteness of Aswan Province on the other hand induces «Cairoits» to consider it as a virtual exile!

2. Geiza province attracts the highest number of «Cairoits» (23,139 or 24.7 % of the total number of out-migrants), this is understandable when it is known that Geiza has acquired the functions of a metropolitan satellite through the improvement of transportation facilities and also because of the presence of Cairo University.

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[1] Gini Corrado, «Considerations on the Optimum density of a population», *Proc. World Population Confer.*, London, 1927, pp. 118-122.

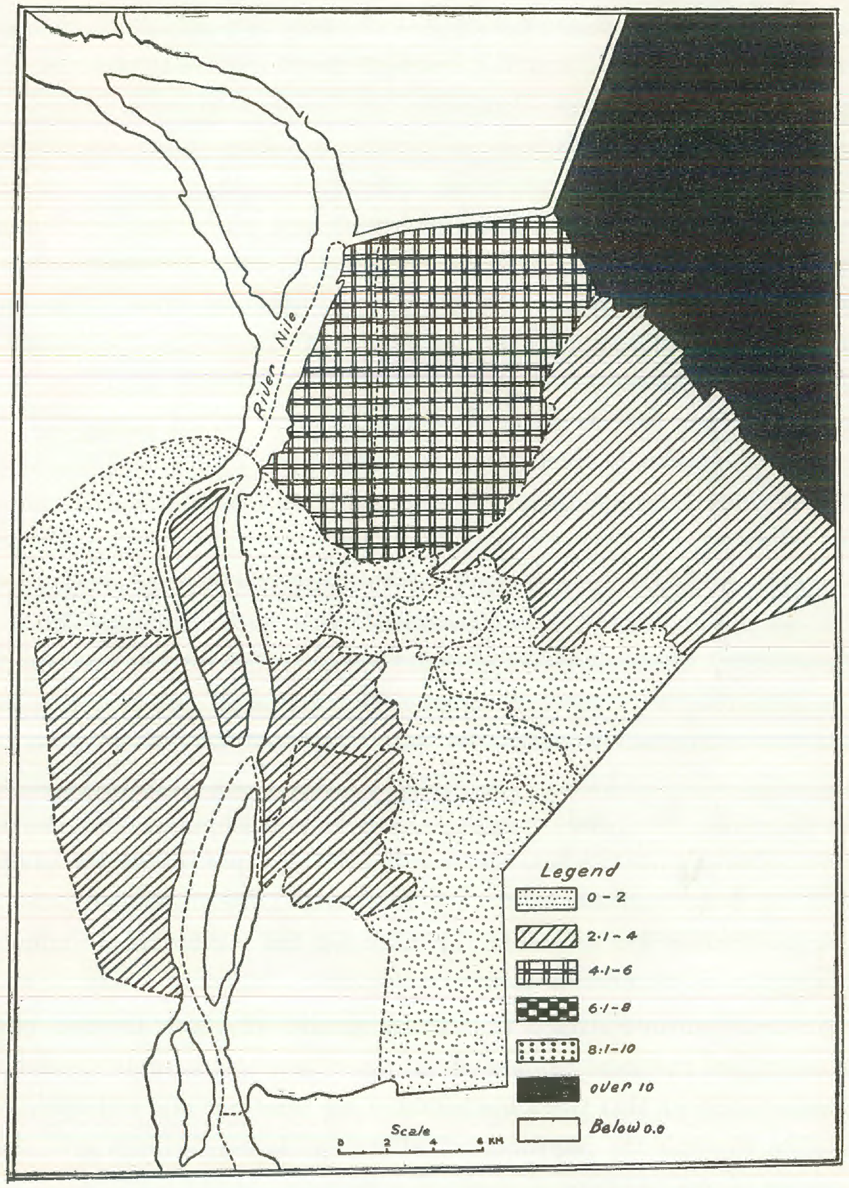

Fig. 4. Rates of net migration in the different districts of Cairo in 1927.

3. Cairo gained in 1947, about 3.5 % (21,143) out of its total profit through migration from Alexandria, the chief port of Egypt. The number of « Alexandrians » residing in Cairo represents approximately 52 °/₀ of the total number of out-migrants from Alexandria [1]. The exchange of population between « the Port » and « the Metropolis » was throughout the three last enumerations in favour of « the Metropolis »; a feature which could naturally be ascribed to Cairo's function as a metropolitan capital with the consequent centralization of administration, ameneties and services.

4. The Suez Canal area with its constant demand for labour owing to the presence of a British military base (in 1947 and up till the 18th of June 1956) and where « Cairoits » and others found vast opportunities for work, was the only area which gained population from Cairo (1,016 in 1947). After the denounciation of the Anglo-Egyptian Treaty of 1936 in 1951, however, a counter-current of migration from the Suez Canal area to Cairo took place, and the Canal area lost population for the first time to Cairo. Estimates revealed the total gain of Cairo from the Suez Canal area in 1951, to be over 80,000; the majority of them come from other parts of the country. Thus the Suez Canal area in 1951, acted to an extent, as intermediary in the process of population interchange between Cairo and other parts of the country.

5. Table (4) readily shows that Cairo in 1947 contributed only 93,349 or 4.4 %, while it drew 693,807 or 32.7 % of its total population from the eighteen provinces of Egypt (including the governorates of Alexandria, Damietta, Suez and Canal). This means a net gain of 600,428 or slightly less than one third of its total population through net migration.

We do not know, however, with any precision what were the components of net migration since only the gross volume of internal migration was computed. This definitely gives a minimum statement of the importance of migration since some of its fundamental items concerning

[1] The number of « Alexandrians » residing in Cairo on enumeration day (27th March, 1947) was 36,511, whilst the total number of out-migrants from Alexandria was 69,327.

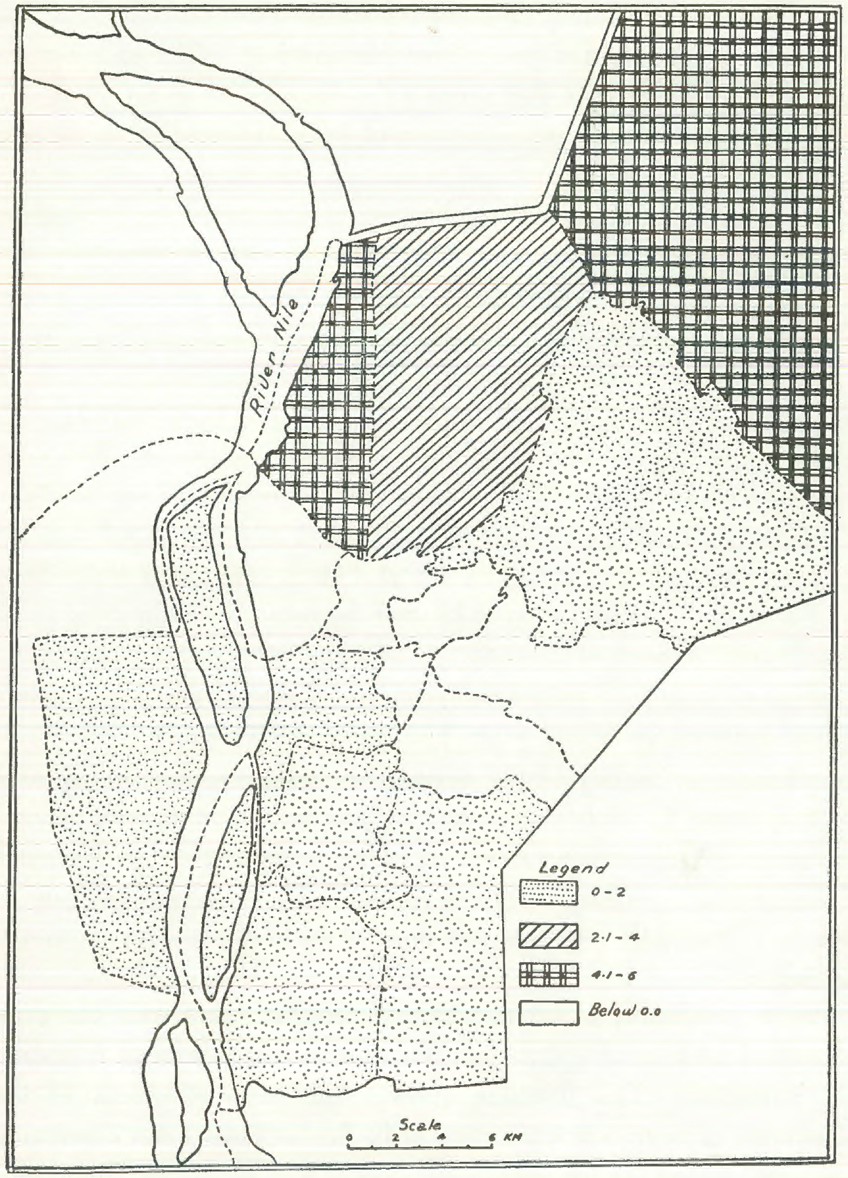

Fig. 5. Rates of net migration in the different districts of Cairo in 1937.

the sex and age structure of its varying volumes, are entirely lacking. This is attributed to the incompleteness [1] of the relevant statistics (censuses and vital statistics).

It is worthwhile mentioning in this connection that the most appropriate method for calculating migration by age, group and sex is based on the subdivision of the total population by sexes separately into five-year age groups. From each age group is deducted the deaths calculated as occurring in that age group during the subsequent ten years. From such a differentiation is obtained the population expected to survive by the end of the ten year period in each quinquennial age group. The figures obtained through this process are then compared with the actual population recorded at the next census and the difference gives the net migration for each age group within the particular sex. However, the inadequacy and incompleteness of the Egyptian population statistics (censuses and vital statistics) will not only hinder and obstruct carrying out a study of this nature, but will render it entirely impossible.

III

Another method for revealing some of the facts about migration in Cairo is based upon discussing the migration component in population change [2]. This method will be adopted here to outline the role played by in-migration in population growth in the different districts of Cairo. We lack however sufficiently accurate direct measures of migration to justify direct computation. Migration therefore will be estimated as a residual, through establishing for each intercensal change the part played in the total change by natural excess or decrease of births in relation to deaths. By differentiating the two, the net migration is obtained. The application of this procedure on the censal returns of 1917-27, 1927-37 and 1937-47 and on the vital statistics for the same period, gives migration rates in the different districts of Cairo. Table (6) shows these rates.

[1] Deaths by age groups, for instance, in addition to their doubtful reliability, were only recently ascertained in the Egyptian Vital Statistics.

[2] Kirk Dudley, «Major migrations since World War II», *Milbank Memorial Fund,* 1958, p. 25.

TABLE 6

Rates of Migration per annum in Cairo during ten year periods (1927, 1937 and 1947)

District	1917-1927			1927-1937			1937-1947		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Azbakia	2.4	0.9	1.5	0.0	1.3	-1.3	3.8	1.4	2.4
Gammalia	2.0	1.3	0.7	-0.1	1.6	-1.7	4.5	1.8	2.7
Khalifa	2.4	1.0	1.4	1.5	1.3	0.2	5.0	1.3	3.7
Darb el-Ahmar	1.8	1.1	0.7	0.0	1.3	-1.3	5.0	1.8	3.2
Mosqui	0.9	1.1	-0.2	0.0	1.2	-1.2	3.9	1.5	2.4
Bab el-Shaariya	1.9	1.1	0.8	1.3	1.6	-0.3	5.2	1.9	3.3
Bulaq	3.0	1.3	1.7	0.8	1.7	-0.9	4.8	2.0	2.8
Abdine	2.7	0.6	2.1	2.1	0.9	1.2	4.3	1.1	3.2
Misr el-Qadima	0.4	0.9	-0.5	3.5	1.7	1.8	7.5	1.7	5.8
Sayyeda Zeinab	3.6	0.2	3.4	2.3	1.8	0.5	5.2	1.6	3.6
Wayli	4.6	0.6	4.0	3.3	1.5	1.8	6.8	1.8	5.0
Rod el-Farag	7.3	1.7	5.6	0.7	1.9	5.1	6.8	2.2	4.4
Shubra	7.5	2.5	5.0	6.3	2.4	3.9	9.2	2.5	6.7
Misr el-Gedida	11.4	0.9	10.5	6.4	1.2	5.2	8.8	1.9	6.9
Cairo	1.7	0.9	0.8	2.3	1.6	0.7	5.9	1.7	4.2

(1) Inter-Censal increase. (2) Natural increase. (3) In or out migration.

The above table exhibits the following salient features :

1. Cairo witnessed a notable growth of its population, a sizeable component of which was contributed by net migration. In 1927 only the two districts of Mosqui and Misr el-Qadima lost population through out-migration. Population growth by net migration, in the meantime, was heavily concentrated in the metropolitan ring especially in its northern part (in Rod el-Farag—Shubra—Misr el-Gedida where the rates of net migration were 5.6, 5.0 and 10.5 respectively).

2. In 1937 the six central districts of Azbakia, Gammalia, Darb el-Ahmar, Mosqui, Bab el-Shaaria and Bulaq were places of net out-migration. The northern parts of the suburban ring were focal points

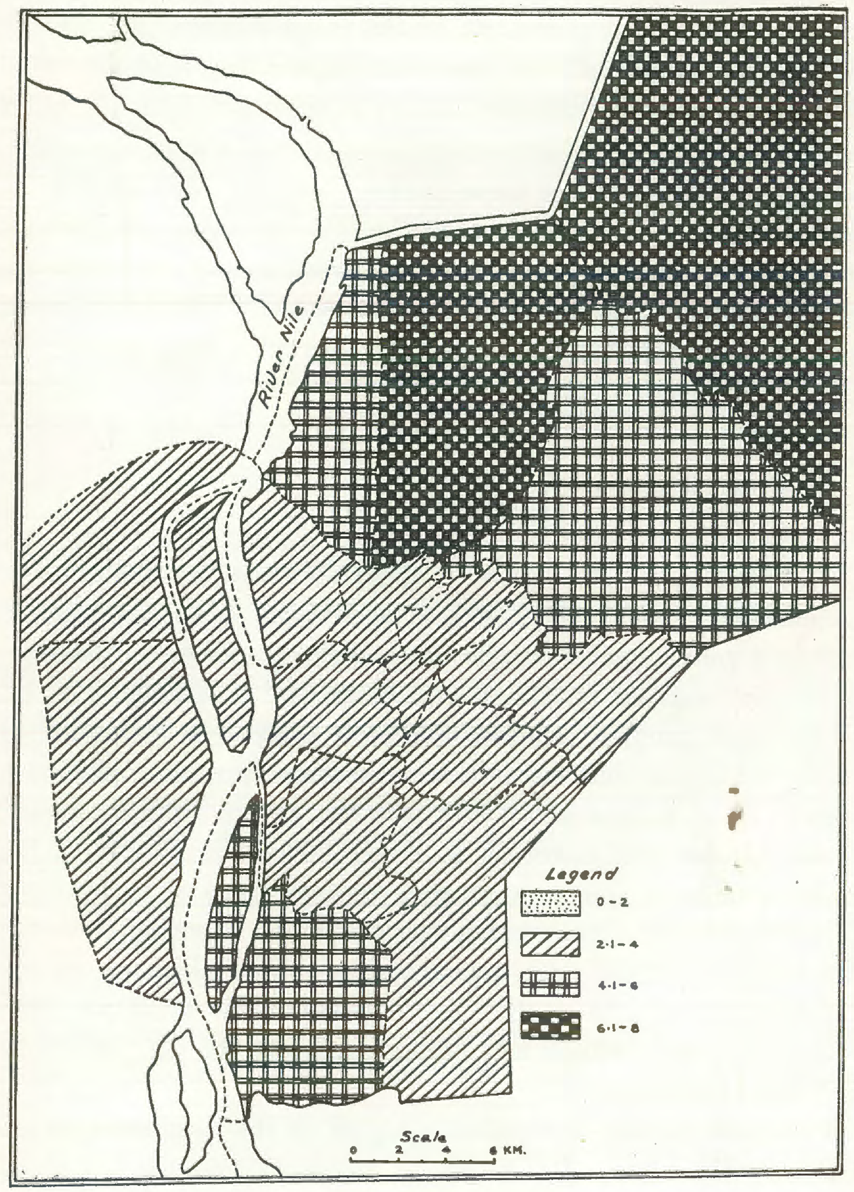

FIG. 6. Rates of net migration in the different districts of Cairo in 1947.

for great net in-migration. The net rate of migration in Misr el-Gedida for instance equalled in 1927 about eleven times that of the natural increase, and in 1937, increase by migration persisted but its rate slackened to almost half the rate recorded in 1927. The economic depression was responsible for this.

3. In 1947 the central districts of Cairo witnessed a relative growth of population. This does not mean however that such districts ceased to become places of net out-migration, but this happened only because their positive reproductive change was great enough to repay the migration loss and permit a little growth besides. The suburbanward movement also persisted and became concentrated in both the northern and southern parts of the outer ring of Cairo.

CONCLUSION

The great inflow of migrants to Cairo obviously contributed to its economic and social wealth. It is a big addition to its man-power as well as a good stimulant to the urban building industry. The influx of so many migrants into Cairo (1/3 of its total population in 1947) on the other hand has brought to the fore many acute problems from which the city is suffering (housing, transport, provision, education, morale ... etc.), and it is hoped with the current tendency towards decentralization that Cairo will no longer become the «Favoured City in Egypt». It is also high time to proclaim Cairo as a closed city to provincial migrants assuming decentralization is not implimented. Since 37.5 % of the total in-migrants come from the three adjacent provinces (Minufia, Geiza, Qaliubia) it is hoped that the improvement of transportation facilities may facilitate entry to the city without the necessity of migration.

Population increase was generally higher on the peripheries than in the central districts. The centrifugal movement from the central city to the area surrounding it, is responsible for this. This « deconcentration» of population was in many areas at the expense of vast acreages of farm land. But the destruction of the agricultural hinterland of Cairo should

be discouraged by every conceivable way, and the sprawl of the city should be directed only to the «*Sand*» (Misr el-Gedida, in the N. E. Maasara and Helwan in the S.).

The above study of « Migration in Cairo» is still incomplete and represents only a very tentative analysis. This could be mainly attributed to the inadequacy of information bearing on this vital aspect of population in the Egyptian Censuses. One can only hope here to stimulate better analysis and more complete inquiries in the future.

PROBLEMS OF IRRIGATION
IN ARID ZONES

BY

ALI SHAFEI

I. INTRODUCTION

1. *Definition :*

Arid zones are from the Agricultural point of view those that require artificial means for concentrating rain or flood waters on the cultivable soil to ensure a crop. It is generally considered to be limited to land with an average yearly rainfall of less than 10″ (25 cm.).

2. *Arid Zones Visited :*

In my work, I have travelled nearly all over Egypt, Saudi Arabia and Jordan, and I have visited for study, the Sudan, Tunisia, Algeria and a part of Tripoli and Syria. These are admittedly among the hardest hit of arid zones. It is not enough to read the privations travellers have seen in the desert, one has to see with his own eyes how man and beast manage to eke out a living in these wastes, and to give the reader an impression of the unfavourable condition under which they live ; I include in this article a photograph taken on a trip from Jidda to Hail. It shows a young bedwin asking for fresh water, the water of the locality being brackish. The camel has solved this problem in some localities by drinking water which is too brackish for human consumption and the few humans that tend the camels drink its milk. Such dreary spots may contain copious artesian water and in many cases have yielded gushing streams and oases started on this water where even wild animals have ceased to exist.

3. *Increase of Population :*

The increase of population has forced many countries to turn to the desert for cultivation, and this was a necessity in countries like Egypt which have no colonies to which the surplus inhabitants can go and find a living.

4. *Lack of Literature :*

I mean technical literature, for although the desert has appealed to romantic writers and many are the books describing sand dunes and breathtaking sunsets and green oases and treacherous mirages that mislead thirsty travellers to a lingering death, yet irrigation text books have given the subject a wide berth. It is only in 1949 that the Irrigation Department of Egypt formed the Inspectorate of Desert Irrigation Projects [1], and since then desert institutes and the UNESCO Committee for Arid Zones have been formed. In the rush, many impostors have grasped the occasion, and it is quite evident that there is great need for genuine information supplied by engineers who have borne the brunt of the battle against the barren desert to weed out all misleading information and unnecessary academic studies which will lead us to nowhere.

II. SYSTEMS OF ARID ZONE IRRIGATION

1. *Irrigation from Rivers :*

In many cases Arid Zones are intersected by rivers and springs. Egypt is an example, for it has no rainfall to speak of, but it has perfected the art of irrigation since 5000 years. The art of diverting streams to land by weirs and canals and flooding by basin irrigation and perennial irrigation has been expounded and commented upon to such an extent as to leave very little for further improvement and the subject of this article is outside this field.

The Nile as I have said before (Lecture delivered in April 1950 at the Congress held by the Egyptian Institute for Scientific Studies) will be

[1] Decree of the Public Works Ministry dated 19 January 1949.

always our main supply of irrigation water for reclaiming big areas from the desert.

The Irrigation Department of the Ministry of Public Works fixed the far future area of Egypt to be cultivated at 7.100.000 feddans limiting the area to be irrigated from the Nile to the land that had been covered with its silt. Lately and especially after the last two world wars when the price of crops rose, many companies and rich land owners succeeded in reclaiming pure desert areas and obtained profitable results. When I advanced the projects of reclaiming about two million feddans shown on the accompanied map, I was opposed by many senior irrigation officers, but eventually the area was approved officially and included in the zone of the Inspectorate of the Desert Irrigation Projects formed in 1949.

The Menayef Oasis Irrigation Project was completed and the sandy land when tendered for sale by the State Land Department found a ready market.

In my opinion that is the best way of dealing with reclamation projects and this does not apply only to Egypt, but it has been proved at great expense elsewhere when reclamation of land was made by government officials. The Ground Nut Project of Tanganika has been elaborately laid out as to the area cultivated in the first, second and third years when 3.000.000 acres were to be ultimately sown with various crops and even the yield in ground nuts was fixed to the last ton. The cost of the project was estimated at L. 23.000.000 and this was the only true figure for L. 23.000.000 were spent and the yield in the fourth year was only 1566 tons of ground nuts and this even was not put for sale. It was kept as seed. The area reclaimed was only 7500 acres apart from 228 acres allotted for experimental farms [1].

In the Western Desert, Mudiryet el Tahrîr was started by reclaiming the southern sandy area. I have previously commented on this project for it was one of those prepared by me, and pointed out that pilot projects for 5000 feddans should be selected in the different land formations which were loamy in the north, sandy in the south and sandy loam in

[1] The Ground Nut Scheme, The Weekly Times 9 Nov. 1949 and notes taken by me from books.

the middle. (See دراسة مبدئية لرى نصف مليون فدان بالصحراء الغربية عدد شهر اكتوبر سنة ١٩٤٩ من مجلة المهندسين – للمهندس على شافعى).

But this remark was overlooked and work was started on a colossal scale on the poor sandy soil and by paid labourers. A pilot project on a small scale was carried out in Wadi el Natrûn with successful results. I am glad to say that the northern loamy area of the project has now been taken in hand and has shown signs of success.

Much experience has been accumulated in Moudiryet el Tahrîr and it has been shown that pure desert sand could be reclaimed and made to yield good crops of cereals and fruit although that was known to us, and has been executed by private enterprise at less than the cost incurred, and I as an engineer who raised his voice to reclaim desert land to give the Egyptian a decent living would urge the Government to carry the work on the lines that have been tried in reclaiming the salty land of the Delta, i.e., by private enterprise, and the Government restricted to pilot projects.

An attempt has been made to reduce the irrigation water factor by applying water by sprinklers. It is still in the experimental stage, but the figure of the cost of irrigation per feddan (L. E. 25) does not warrant future extension except for forming some beautiful scenery on the Cairo-Alexandria Desert Road. The water is pumped by deep well pumps fixed in wells that reach the water bearing sands that infiltrate from the Rosetta branch to the Wadi el Natrûn depression with a gradient of 0.30 m per kilometre.

The trouble now is that we have no surplus stored water and when the Sadd el Ali impounds water I recommend the « Irrigation of the Wilderness of Etham » project which appeared in the Bulletin of the Société Royale de Géographie d'Egypte, May 1948, for it will reclaim Northern Sinai, and Nile water will reach El Arish. The Menayef Oasis project which has been executed and the land sold to local inhabitants is part of this big ambitious project. It has a further benefit for it will protect the Suez canal now in Egyptian hands from desert blown sand and crops grown will have a ready market being on one of the main maritime transport lines.

Needless to say both irrigation projects on the Western and Eastern Deserts of Egypt require the planting of trees on the main canals without waiting until they are dug for they will be filled with sand. Engineers should visit and see for themselves the 5 kilometres on the left bank of Rayyah el Behera at Teirya and Olkam and how the four rows of eucalyptus trees and a fifth line of acacia salignum on the windward side [1] have stopped all drift sand and saved the canal.

The project for reclaiming one million feddans of « sabakh » land in the Qattara Depression has yet to await results of the experiment of reclaiming similar land in the Naqb at Siwa.

2. *Dwarf Dams (okkad* عُقّد*)* :

I would like to lay much strees on the importance of building these dwarf dams in arid zones on wadis, 2.0 m high and 2.0-2.5 m thick. I have seen, in Tayef at Wadi Mahram a branch of Wadi Masara, six built by Abd el Wahab el Halawani 4.0 m high and beautiful gardens upstream them, and near Mersa Matruh Abd el Latif el Zayyat built three dams 2.0 m high) and had a successful garden of olives and almonds. Midway between these two sites I have seen in Palestine near Auja ruins of hundreds of these dams at Abda in 1942 and it seems that the Nabateans who lived there during the Roman period and who were the merchants that carried the spice trade from Yemen to the Mediterranean on their camels found that this is the best way of reclaiming the arid desert of Negb. It is interesting to note that their name implies that they are « water finders » انباط and it may be assumed without much error according to the studies of Mr. G. W. Murray that rainfall 2000 years ago was the same as now [2].

These dwarf dams should be constructed in regions having an average rainfall not less than 100 mm per year. Both men told me they consider their dams a successful financial investment, for they grow gardens on the silt accumulation and even in years of drought I have seen the gardens

(1) The prevailing wind in Egypt is N. W.

(2) Desiccation in Egypt, Bulletin de la Société Royale de Géographie d'Égypte, November 1949, p. 19-34.

with green leaves but a poor crop. These gardens provide the locality with a settled population tending their flocks and when rain falls cultivators with seeds will be near at hand to grow and tend the fields instead of wasting the precious water.

The Government should take a hand in building such dams for the inhabitants are poor and are unable to finance the building of these dams. Twelve years ago Abd el Latif spent L. E. 700 on his three dams but he says he earns L. E. 250 in a good year now [1].

3. *The Flood System :*

This is widely practiced in Arabia. When one travels by aeroplane one wonders at the industrious bedwin utilising every drop of water by building earth banks called Ogom to divert the flood waters of wadis. In Egypt, I have seen on the upper Wadi el Arish one at Difidif and another at Mit Mitni; in both they tried to build a masonry dam but it failled, and should be built by the Government.

It is in the Southern Tihama of Asir that I saw this system near Yemen at its best. The Monsoon rains falling on the Sarah highlands at the same time as they fall on the Abyssinian mountains make the wadis of Sabya, Gizan, Dhamad and many others run in spates. At the foot of the mountains in the plain, a series of earth dams are made and canals take upstream to feed a number of small basins. Much improvement could be made by building the Ogoms in masonry and building masonry heads to the feeder canals to close them as soon as the basins are full and the waters diverted to the water systems instead of breaching the Ogoms and then reconstructing them after the flood at great cost by wooden scrapers drawn by cows (They have very beautiful small oxen). This is what the Sabayan kings of Yemen did more than 2000 years ago. The Marib dam is an example. It is a masonry Ogom with two sluice heads one on the left and one on the right. The left sluice had two openings and feeds a masonry channel more than 1500 m long and at its end has a basin with outlets on the system of the Fayoum weirs to divide the water among the villages.

[1] Probably he exagerates. I consider L. 150 a more correct figure.

Now, matters have gone from bad to worse and I believe the first thing that should be done is to repair this wonderful dam, if only to remove the curse mentioned in the Koran. The repair of the Maarib dam is not only an act of preserving a famous Arab monument, but it will shed light and provide technical information of prime importance to aid in the design of irrigation systems in arid zones.

In years of high floods, the Ogoms are breached by the water before it has done any good and thus good years may turn out to be calamities for the wadi often changes its course and scours the villages and the poor inhabitants barely escape with their lives, leaving behind their seeds which are lost.

The weirs could not be designed properly without enough records of the floods and meanwhile much good has been done by supplying the peasants now-a-days with bulldozers to build the Ogoms instead of using the cows, but the Ogoms have to be built in masonry and the head sluices also if enough food is expected to feed the hungry inhabitants.

The F. A. O. engineers who were called to study Wadi Gizan made an aerial survey of the zone and started meteorological and hydrological observations for one year and designed the Ogoms of blocks of stone crated in meshing to cut down the cost of transporting cement. They also recommended a «spate» breaker» in the form of a sizable dam with an open sluice erected in the mountain to check the flow of the dangerous floods, but its effect on the silt carried by the torrents was feared. The silt is a very efficient manure to the millet which grows to luxurient size and yields up to three crops in a good year. The peasants call it «Hayat el Ard» or life of the soil and depriving the water of it would derange their cultivation for they do not use manure. It is a pity that the masonry Ogoms and head sluices were not built. Instead, the authorities were content with supplying the land owners with bulldozers to form the Ogoms, but the meteorological and hydrological observations have ceased to be taken which is also much to be regretted.

4. *Karm System :*

This system was practiced in the Western Desert on a 20 kilometre strip of the coast. On going to Alexandria on the desert road, you will

cross their banks and see if you examine the section that they were made by scrapers which require oxen to draw them as in wadi Gizan which I have described. Now the karms are in ruins and cows are only found in Tripoli. I have seen karms in Tunisia in 1950 near Gabes where the rainfall is not more than that of Mareot. I suggest that some of them should be repaired with bulldozers. They have to be provided with ditches to collect the run-off and also have spillways called by the Tunisians « Manfath ». They often breach due to the holes made by the « Gerboa » or desert rat. Earth dams properly located and as now practiced about Ras el Hekma will do a lot of good if extensively practiced.

5. *Open Wells or « Sanias »* :

These are the main source of water in arid zones and their name which means two is derived from the fact that generally a well serves two leather buckets « Dilw » pulled by ropes by two animals, if three are used they call it « Thaltha » and if one only it is called « Farida ». I have seen one at Oweina in Wadi Hanifa with 15 buckets pulled by as many donkeys which must have eaten a big part of the crop. Now Ruston oil engines and pumps have taken their place with unwelcome results for the water table has fallen as much as 20 m, and unless some laws are issued to limit the number of wells more trouble looms ahead.

A feature of these wells in Arabia is the property of the silt to stand vertical without lining although it is sandy mixed with fine clay which binds it, and I have seen some more than 15 m deep.

6. *Deep Wells :*

The need for more fresh water in Riyadh especially after the Ministries have shifted from Jidda to that capital warranted trying to find deep artesian water which was actually found by the Hydraulique Afrique Company using the Layne system at a depth of 1200 m A previous attempt by Aramco reached 800 m when only salt water was found, and the company said that it is not probable that fresh water could be found deeper. Previous geological studies made by German geologists have shown a strata of sandstone more than 800 m deep [1] and when the Hydraulique Afrique men were shown these sections, they accepted to

[1] The sandstone was covered and underlined by impervious marls.

work and be paid only the salary of their staff, fuel and transport. Should they find fresh water they would be paid for their work. They succeeded at last and that was three years ago, and I understand they have signed contracts for more wells; and finished 2 more wells.

Deep wells are costly and should receive great attention to guard against their collapse due to rust of the tubes or screen and choking with sand. For this reason deep wells should be cemented and provided with non-corrosive screens enveloped in graded silicious gravel of ample thickness, and for this reason only companies of known fame and integrity should be entrusted with the job or else trouble will follow the successful rush of water and the discharge decreases much. Wells should be provided with sluices to close them when water is not needed instead of letting the water run to form pools and breed mosquitoes.

7. *Kanat or Underground Aqueducts :*

An ancient example of them has been found in Baharia oasis and was proved to be made in ancient Egyptian times for a chamber in a tomb of that period was proved to have been shifted to avoid interfering with the aqueduct, but the Persians used them extensively and have introduced them in Arabia in the beginning of Islam when vast riches poured into the country. Hardly any wadi has been left without its « doubles », and one must guard against their presence when building dams in these valleys for they will undermine them in flood. The beds of wadis are sandy and even gravelly and during floods a big percentage of it infiltrates into the bed and runs slowly. Opinions differ on the travel of subterranean water and experiments on this subject are much needed. In the Hijaz, the wadis run in igneous rocks which are like cast iron in their retention of this water and lie generally from 10-15 m below the surface of the bed. Its top, two metres, is fissured by the dissolving action of water and is the source of water in the wells. This water is collected in the gallery and run at a flatter slope than the bed of the wadi. Generally, the slope of the bed of the wadi is 6 metres per kilometre, and the aqueduct runs at 1.0-0.5 m per kilometre and as the ground water is 8-10 m below the bed, so the aqueduct after running 1.5-2.0 km runs free flow on the ground and irrigates the berms of the wadi which are

safe from the torrents and to guard against erosion they are protected by stone walls (ضفيرة) and the garden is called (خيف pl. خيوف). The famous palmeries of Medina lying to the north of the town and west of Ohod mountain are a good example and are fed by the subsoil waters of Wadi el Aqiq, but now they suffer from the lowering of the water table for to the south of Medina the gardens have been irrigated by wells worked by animals, but now oil engines and pumps have been widely used and as I said before laws should be issued preventing the ruthless installation of these pumps.

There are laws in existence all over Arabia, I have studied some of them. This law is called (عُرف) and the most elaborate is that of al Ula north of Medina and near Madain Saleh where the Nabateans of whom I have previously talked as excellent water engineers left their ruins, thus through the ages the art of water control has persisted. I recommend that the Saudi Government should collect these laws and form of them one law similar to the « Canal and banks» law in Egypt (لائحة الترع والجسور) instead of leaving each community to work regardless of the harm it inflicts on her neighbours. It is interesting to note that I have compared the price of water for irrigating a feddan on the aqueducts of Sayh in Aflaj and found it L. E. 4 which is very near the tax on land in Egypt. In Algeria and Tunisia, water stored in dams is sold at one franc a cubic metre and that would make it about the same price (not counting the rainy season when stored water is not used).

The famous Zobeida aqueduct which feeds Mecca with water was started by Queen Zobeida wife of Harûn al Rasheed of Arabian nights fame. In the early Islamic period the pilgrims drank from twelve wells of which the famous well in the Ka'ba was one, but when Islam spread, these wells were insufficient for the pilgrims and water had to be carried from far and sold at exorbitant prices. The aqueduct starts in Wadi No'man more than 22 km from Mecca and its water is dammed by a natural underground dam just east of Arafat. For this reason it is not much affected by years of drought. The inspection chambers خرز at its source are the deepest I have seen, being about 35 m deep. A description of this aqueduct and its repairs in years of heavy floods when the wells are scoured and the aqueduct filled with sand is given in my book مشروعات عمرانية بمكة المكرمة والطائف and also is shown the project I suggested for feeding Mecca from Wadi Ibrahim from some of its springs by a pipe-line. (The project has since been executed as the new « Ain Abd el Aziz»).

I will never recommend these aqueducts for they are very costly and I remember Sheikh Abdullah Soliman the ex-Minister of Finance and a millionaire when he started clearing a small aqueduct east of the Jidda aerodrome to irrigate a vegetable garden, but he stopped the work for it was expensive as he himself told me.

Pipe-lines have done wonders for municipal water supply in Arabia, and I recommend any civil engineer who is delegated for work there to prepare himself for such work.

The water supply of Mersa Matruh depends on the old aqueduct in the oolitic limestone to the west of the town. The rain water that falls on the plain floats on the salt water and flows to the sea. The aqueduct intercepts it and if pumping is excessive and the supply of fresh water is less than the demand, salt water is pumped.

Before the late Th. Yennidunia built the Marathon dam for the water supply of Athens, that city depended on an old aqueduct for its supply.

These aqueducts require a lot of maintenance and after heavy floods the inspection chambers خرز are destroyed and sand enters the aqueduct, now with the high wages of labour the poor peasants cannot afford to pay the expenses and many a prosperous village has been forsaken and its palms are dead, but these aqueducts should be maintained and the Saudi Government can do well if it offers a prize for any mechanical invention that can facilitate the clearance of these aqueducts, it will help reclaiming many villages and bring back to them prosperity.

8. *Irrigation From Drainage Waters :*

Deserts bordering an irrigated area can benefit by using the drainage water instead of letting it go to waste in marshes or the sea. This is possible because sandy soil drains well and can stand a higher salinity of its irrigation water that would have barred its use in oridinary soils.

El Hofûf oasis uses its drainage water and oases like Siwa uses water with 4000 p. p. m. dissolved salts and Qaret Om el Saghir in the

Qattara depression uses water with 6000 p.p.m. and grows very good olives on it. I had two tins of this olive in my house and they were not inferior to Greek olives.

For this reason I recommend the Mareot project depending on water pumped at Mex and thrown to the sea for it contains 2000 p. p. m. salts whereas the wells of Amrya and Borg el Arab contain 4000-6000 p. p. m.

Studies of extending cultivation in the Oases of Kharga and Dakhla should include draining the low lands and pumping its waters to higher grounds where palms could be cultivated. In Dakhla, there is a big area of land dotted with old mounds that had artesian wells and the land is salty, why not try to reclaim this land and make a pilot project as an experiment.

9. *Storage Dams :*

The great drawback to storage dams in deserts is that flood waters contain a high percentage of silt, and the dams are soon silted. In my opinion they should only be used for replenishing ground water, a subject of prime importance in arid zones and which I will explain later. When I lately made a tour of the Western Desert, I recommended a big cistern constructed downstream El Garawla dam that can store 25.000 m^3 for drinking in Mersa Matruh during the summer, for the dam is near the pipe-line. Such an experiment would have done wonders in improving the water supply if carried out in several localities and would repay its cost.

I would recommend a 50.000 m^3 cistern downstream Rawafa' dam and a similar one downstream Tayef and Akûl (Medina) dams.

I would prefer dwarf dams on the desert torrents to storage dams, and downstream such dams cisterns could be constructed.

III. REPLENISHING GROUND WATER

The discovery of oil in the Middle East has caused a drastic change not only in the mode of life of the Arabs, but also in the irrigation of their gardens and cultivation. Oil engines on deep well pumps have

caused the water table to fall continuously. Before that the old wells worked by donkeys were discharging far less than now and in Wadi Hanifa near Riyadh the water table was 10 m below the wadi bed, and that was only ten years ago. When I left in 1956 the water had fell 25 m below the bed. American experts delegated by the Aramco at the request of the Saudi Government according to the terms of the oil concession suggested the following proposals which it has been my good fortune to study as an adviser on hydrology to the Saudi Government in 1954 :

1. Building check dams.
2. Building an underground dam.
3. Issuing laws to prevent further exploitation of ground water without a permit.

To these, I spontaneously agreed and designed and started building a check dam north of Riyadh which has been completed last year and filled last January with a seyl. The lake U. S. the dam was a grand sight for every body, whereas it should have been discharged to replenish the ground water. Worse than that they raised the sill one metre thus halving the spilling capacity and endangering the dam in dangerous floods. My proposal was to build more check dams D. S.

The underground dam was a big undertaking for rock was met with 60 m below the bed and fissured and liable to leak downstream and for this reason, Dr. Brown, the geologist, loaned to the Saudi Government by Point Four suggested and executed a pumping station 40 km downstream Riyadh and pumping the water back 90 m plus friction in pipe [1]. The water at Riyadh contains 500 p. p. m., but at the new site it contains 1500 p. p. m. but what could they do, water was much in demand after Riyadh has become the capital.

I suggested pumping water at Gebeila where it is very fresh and 50 km upstream Riyadh and water will flow free, and now they are considering executing it, but believe me that would relieve the position for the time being.

[1] I heard that the ground water has fallen much and the supply is helped by the cleep wells lately constructed at Riyadh.

I carried the studies of the subterranean dam and as an engineer I wanted to see and study an actual example. That came four years ago when I met the famous Italian engineer Luigi Galioli who has executed a dam of equal dimension to the subterranean dam proposed by the Aramco engineers for Wadi Hanifa and recommended the help and advice of that engineer to the Saudi Government, but no step was taken in that direction, and my knowledge of subterranean dams will continue to be of an academic nature.

The issuing of the law prohibiting digging wells without permission has not taken place until I left although it was the most important, but the finding of a water bearing strata of sandstone at 1200 m below Riyadh and its exploitation may ultimately solve the problem [1].

IV. DRY DAMS

These are dams built on wadis with impervious rock beds such as the igneous rocks of Hijaz. These dams will be filled with pebbles and sand and silt, but water to the extent of 25 % of their capacity will be stored and shielded from evaporation and will be a useful water supply in the desert. I hoped the Rawafaʿa dam would act as such, but alas its silt is bone dry and water escapes in the limestone fissures. The Tayef dam which I built also has an old channel of the wadi by which the water impounded seeped back to the wadi and replenished the Tayef aqueduct, and the Akûl dam (Medina) is built on fissured lava where the water escapes quicker than the Rawafa' dam, and we have still to wait and see successful dry dams of any importance.

I was told that the Dutch store flood waters in the coastal sand dunes and it would be very interesting to apply that in our coastal sand dunes. The water melon growers of Qalabsho at the tail of Hafir Shehab el Din canal do something similar.

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(1) I understand that 3 of these wells have been completed, and by restricting their water to irrigation and municipal requirements will help ease the situation.

V. THE PRICKLY PEAR CACTUS

This has been introduced about 50 years ago in Tayef, and has shown great adaptability to the conditions of its mountains. It spread because its fruit is relished by the inhabitants and helps to save 25 % of the cereals as I was told by Sheikh Kazzaz. To me it was a great help in conserving the rain water on the slopes and feeding slowly the ground water so much that I recommended means taken by the governors to encourage its cultivation for I have seen it withered and dry in dry years, but as soon as rain fell it sprang to life again.

VI. DRAINAGE OF SWAMPS

I strongly recommended the drainage of swamps in arid zones. I dedicate this article to the memory of my friend the late Hussein Badawy the Egyptian expert on agriculture to the Saudi Government in Dammam, a very malarial marsh. When I visited Qatif with him and saw the poor health of the cultivators, he told me it was malaria and that nobody who spends some nights there comes out without contracting it. (I took one pill of paludrine every three days as a precaution just before entering the oases). He also told me of a rhyme that Qatif always claims the foreigner.

In my recommendations for projects in Saudi Arabia, I consider that priority should be given to the drainage of Qatif, for not only man and beast will benefit, but the land will treble its crops and allow for vegetables of all sorts and fruit to be cultivated, for now only palms and alfalfa برسيم حجازى grow and vegetables for the staff of Aramco come by plane from Lebanon.

In the Jordan, in 1950, I recommended the drainage of the 16.000 feddans of the Azraq swamp and the swamp being at R. L. + 500 m and the Jordan valley at R. L. -250 m, the drainage water which was fresh (used for drinking on the tap line) could develop electricity and reclaim land in the Jordan. I am glad to hear that the F. A. O. have carried out part of this project. In Egypt the most successful projects are the drainage of the North of the Delta.

The salt, with the highest evil effect on plants, is sodium chloride or ordinary salt. With water having 3 grams of soluble salts per litre, sodium chloride should not exceed 30 %.

The most sensitive plant to common salt is the violet, but it is of no practical value in the desert, next come lentils and beans then cereals and kitchen vegetables and at the end of the list beet, spinach, cabbage, cotton and fenugreek.

The following is the maximum quantity of common salt in grams per kilogram of soil that can be borne by the following plants :[1]

Plant	NaCl
Cotton, dates, and olives (poor)	6-8
Cabbage, beet, and lucern	5-7
Wheat and barley	4-5
Cotton-thiving	3.5
Maize	2-3.5
Tomatoes, melons	2-3
Potatoes, carrots, onions, citrus fruits (poor)	1-2

It will give me great satisfaction in my old age to hear that this warning to irrigation engineers has been heeded for they must drain every swamp and make their projects useful to the peasants instead of ruining their health.

I cannot leave this article without regaling the reader with what a young Arab poet told me at Thumala dam in Tayef when he asked me what I was going to do taking measurements of the old dam. I told him I wanted to repair the dam so that when the rains came it will be filled with water, and he said that they are better off without that, saying on the spot :

اذا هبت العوالى اربعين صباح
يصير الماء سفاح والعرب طياح

[1] With the exception of date palms and olives, the figures are taken from «Utilization of Saline Water», an Uneses Arid Zone Research book : price 600 Fr.

واذا هبت الصبا اربعين صباح
يصير الماء شحاح والعرب نصاح

When the southern wind blows forty mornings,
rainfall is plenty and the Arab in poor health;
but if the eastern wind blows forty mornings,
the rainfall is little but the Arab is healthy.

VII. PROTECTING CHANNELS AGAINST WIND BLOWN SAND

This subject has been discussed by me in a note published in the Bulletin of the Royal Geographical Society of Egypt in May 1953. The menace to any channel dug in the desert is very grave and engineers should start planting trees on the alignment of the main canals by constructing pipe-lines before digging these canals.

Rayyah el Behera runs near the Western Desert at Teiriya and Olqam for about 5 km. This resulted in silting the canal to 40 % of its dredged sections in 1932, no wonder the Irrigation Department stopped all reclamation in Behera province until a solution was found.

It was evident that the big area of desert west of the Rayyah and Nubaria must depend on the Rayyah el Behera and as then I was Director General of the newly formed Desert Irrigation Projects, the matter was taken in hand, and four rows of eucalyptus trees, two metres apart, and the rows 3.5 m apart with a fifth row of acacia cyclops on the windward side, were planted and irrigated regularly for three years when the roots of the trees reached the water table and needed no more irrigation. The trees have saved the canal from drift sand and the menace of drift sand removed as sections of the canal have shown. I have written about this in detail for I consider it of vital importance and should be followed in all the canals or drains running in sandy deserts.

In more exposed positions two lines of defense are made, a ten metre strip then an open space 40 m wide, then twenty metres next to the channel. I recommend the eucalyptus for it is a fast growing tree and resists drought and its wood has been proved in the decking of the Sherbin bridge over the Damietta branch to be of superior quality.

The acacia cyclops is needed to fill the gaps between the trunks of the eucalyptus trees for it spreads and does not rise, and is very resistant to drought.

In Arabia, I have seen the «ithl» used very much for the purpose, from Hail in the north to Al Aflaj in the south. Its wood is very much in demand for roofing.

I have given details of a successful attempt to protect one of the main three feeder canals of the Delta, but every case requires a solution and I recommend those interested in the subject to read the note I have referred to at the beginning of this article.

VIII. LINING CHANNELS

In arid zones, water is very precious and should be conserved especially as the soil is sandy and percolation is high, and in a moderate water course as much as 50 % of the water is lost by percolation.

Various methods have been used such as slabs of cement, mechanical machinery and sprinkling with crude oil or lining with clay or even cutting the canal to a bigger section and letting the silt settle and reduce seepage.

In the deserts of Algeria and Tunisia I have seen supported semi-circular conduits of reinforced pre-stressed concrete to let the sand borne by the wind pass under the channel. In the conduit which fed the fort built at Emayyid by Sultan Zahir Beibars which I have uncovered, the conduit was covered by stone slabs for this purpose; and as the project of feeding El Dira' el Bahary from the drainage pumped at Mex is now being revived, the question of protecting the canals running in this sandy zone should be studied.

IX. RAIN-MAKING

This pamphlet would be incomplete without referring to the much discussed rain-making hoax. That was ten years ago when experiments were made by a famous electrical company which proved that under certain conditions of cloud formation, the clouds if sprinkled with

powdered solid CO_2 or subjected to the vapours of silver nitrate, they could be made to yield rain, but the expense far exceeds the amount of rain, and the matter has died a natural death.

X. WATER FINDERS

I have seen them in Arabia and they call them «sannat» or hearer for he is supposed to hear the water running inside the ground. They know from experience and jealously guarded technique handed from father to son information about sites of underground water, but they are not to be relied upon for I have seen much complaint against them.

XI. GEOLOGICAL AND GEOPHYSICAL STUDIES

I have tried instruments much advertised in magazines that would show the presence of underground water and some of them or at least the one we bought professed to show whether the water was fresh or not, but it proved an utter failure.

Nothing compares to geophysical studies carried out by a competent geologist of experience, and this has been shown as I said in finding fresh water 1200 m below Riyadh. Previous geological and geophysical studies by Mr. Alfred Weinreich and his assistant Dr. Konrad Reul who have studied the strata of the escarpment of Gebel Tuwaiq to the west of Riyadh and regions to the west, for three months, found that water bearing sandstone may be found at 870 m below Riyadh, and when their studies were shown to the Hydraulique Afrique engineers they, after conducting their own studies, undertook under responsibility to make a trial bore and water was found at 1200 m.

For this reason, geological studies must be encouraged and geologists of experience and geophysicists should be included in the staff of institutions and departments boring for water. Not only water will be found in out of the way places, but in many cases minerals and fuel may be found as has been shown in Algeria and Egypt.

XII. UTILIZATION OF SEA WATER

Sea water contains 35 grams per litre of dissolved matter of which sodium chloride represents 30 parts, and its alkalinity PH = 7.5-8.4. Many of the deserts are bounded by the sea, but alas up till now methods of making sea water potable (leaving aside irrigation) have proved expensive. It has been shown that to distill sea water to obtain the water supply of Los Angeles one quarter of the oil supplied by the California oil wells has to be used. The cost has been estimated by a Unesco Arid Zone Committee publication [1] at $ 3 per 1000 gallons or $ 0.75 per cubic metre so that in a place like Jidda it will cost $ 1.50 or P.T. 60 per cubic metre.

Solar distillation should prove more efficient in countries like Egypt and Arabia. The absorption of solar heat has been estimated by Mme Telkes as 68 % and assuming the solar heat in hot desert areas 2000-2500 B. Th. U. per square foot, a gallon of distilled water will require 4 sq. ft. and the average yearly area of distiller in California 15 sq. ft. and in Algeria 11.8 sq. ft. She estimated the cost of an acre foot of water (1200 m^3) at $ 260 or 22 cents per cubic metre, and owing to the high price of glass and wood in Egypt we may assume a cost of P.T. 15 per cubic metre.

In my opinion this method should be tried in towns on the Red Sea or even Mersa Matruh, El Arish and Tor.

XIII. ARCHIVES

A proper filing system for information gathered about rainfall and discharge of torrents should be strictly observed for on such information proper designs of irrigation works depend and I hope the filing system and files for hydrology established by me in the Ministry of Agriculture in Saudi Arabia will continue and keep from loss all the drawings and reports of the various experts and committees that have cost the Government much expense.

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[1] Utilization of Soline Water.

I should suggest that educated persons living in remote parts should be encouraged with a reward to collect such information as rainfall temperature, evaporation and discharge of torrents and instruments supplied to headmasters of schools as part of their « ohda» for this purpose.

CHART I

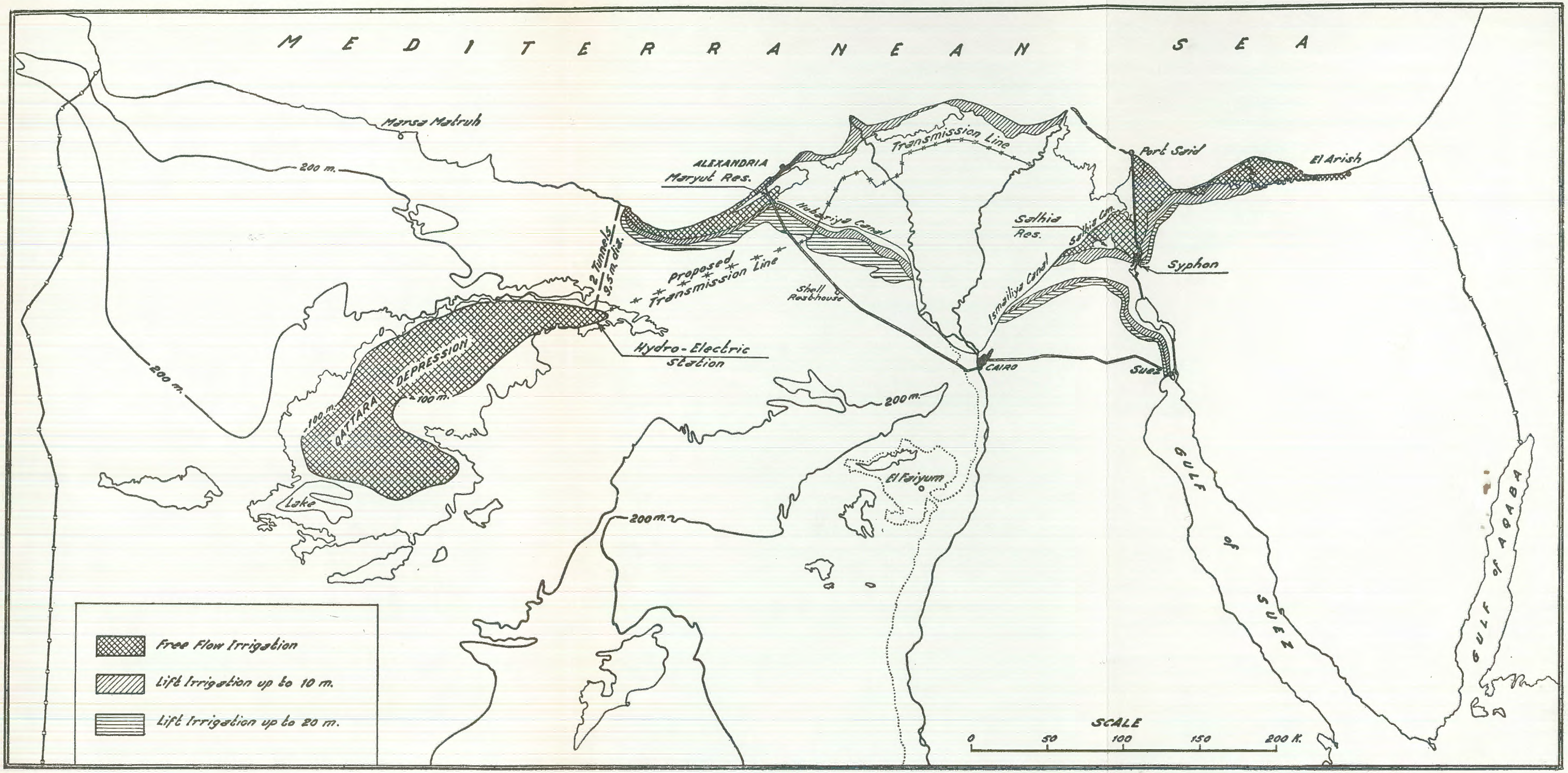

MEDITERRANEAN SEA
Marsa Matruh
200 m.
ALEXANDRIA
Maryut Res.
Transmission Line
Port Said
El Arish
Nubariya Canal
Salhia Res.
Salhia Can.
Syphon
2 Tunnels 9.5 m. dia.
Proposed Transmission Line
Shell Resthouse
Ismailiya Canal
Hydro-Electric Station
CAIRO
Suez
QATTARA DEPRESSION
100 m.
-100 m.
200 m.
Lake
El Faiyum
GULF of SUEZ
GULF of AQABA
SCALE
0
50
100
150
200 K.
Free Flow Irrigation
Lift Irrigation up to 10 m.
Lift Irrigation up to 20 m.

Photo 1. A Check Dam on Wadi Hanifa at Masané 150 Years old.
Its spillway gave the amount of maximum floods.

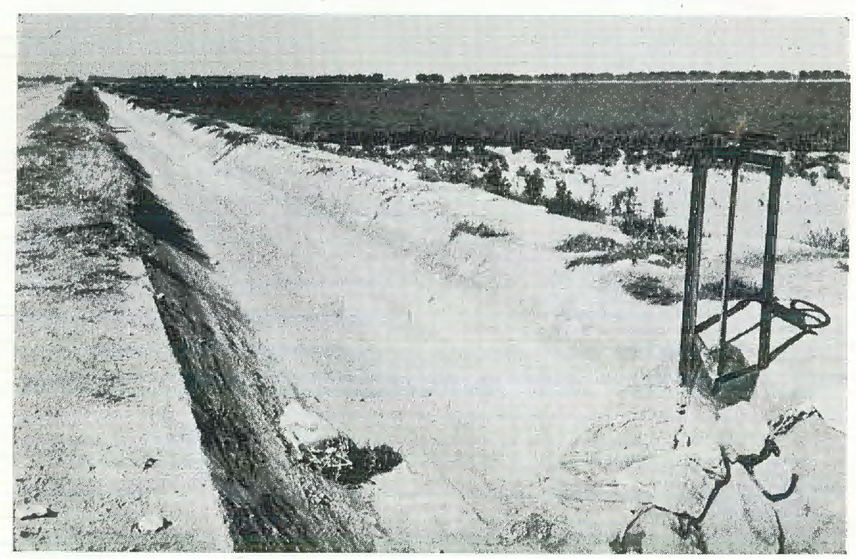


Photo 2. Water courses in deserts have to be lined.
Al Kharj oasis.

Photo 3. Tank Reservoir on the pilgrim Road to Mecca built by Queen Zobeida.

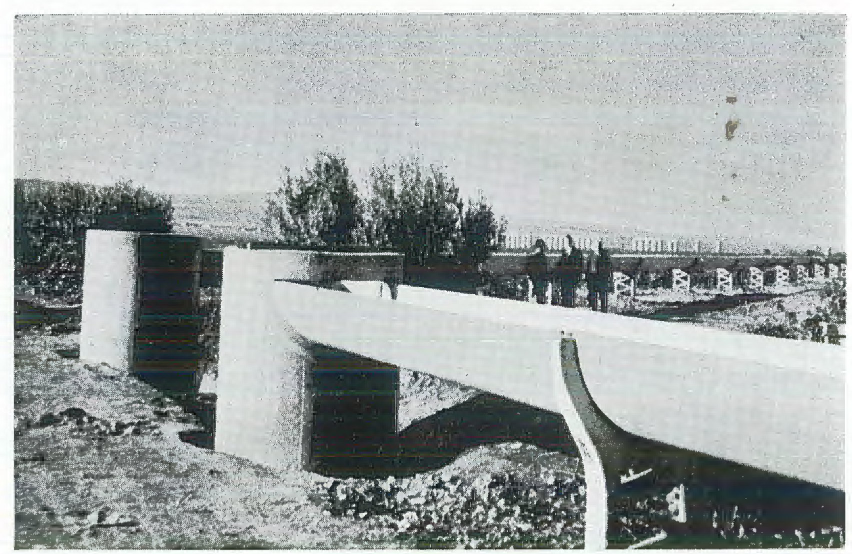


Photo 4. Prestressed reinforced concrete aqueduct in Tunisia.
The old aqueduct of Carthage is on the horizon.

Photo 5. Garden of Olives and Almonds formed upstream three dwarf dams. Wadi el Zayyat.

Photo 6. In many localities the young arabs are glad to obtain fresh water from passing cars.

Photo 7. Taïf Dam built by the author in 1953.

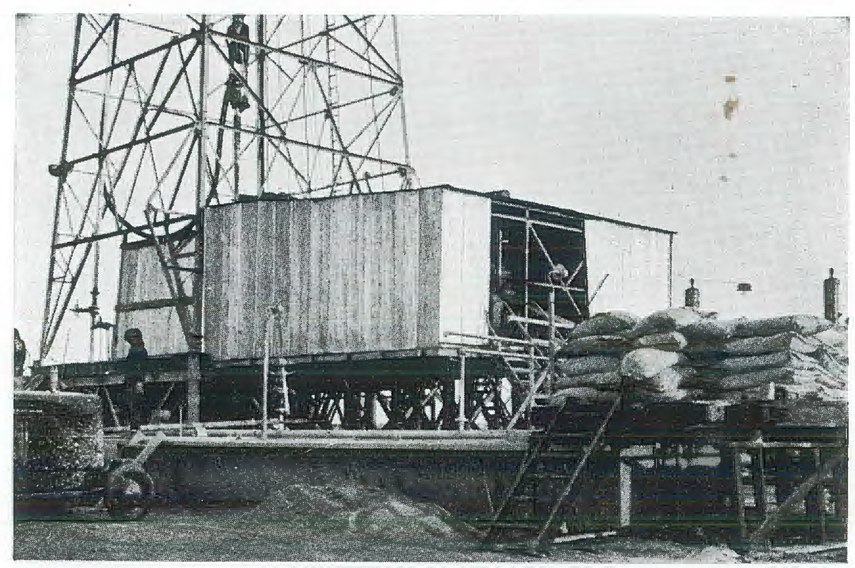


Photo 8. This rig obtained fresh water at Riyadh at 1200 metres depth.

ECOLOGICAL OBSERVATIONS IN WESTERN AND SOUTHERN SINAI

BY

A. M. MIGAHID, M. EL SHAFEI ALI, A. A. ABD EL RAHMAN

AND

M. A. HAMMOUDA

INTRODUCTION

A lot of research work has been done since the early years of the present century on the geology, geomorphology and geography of Sinai. Among the important studies in these fields may be mentioned Awad (1941, 1949, 1951 and 1952), Ball (1916 and 1939), Barron (1907), Beandell (1927), Bowman (1931), Hume (1904, 1906 and 1929), Moon and Sadek (1921, 1922 and 1923) and Shata (1954 and 1955). Although Southern Sinai represents one of the main phytogeographical regions of Egypt yet a thorough study of the vegetation of this region and its distribution in the different parts in relation to habitat conditions has not been made so far. Apart from plant collecting and studying of the flora the only ecological studies made in Southern Sinai were those of Zohary (1935) and Hassib (1951). These are of rather general nature. The need was felt, therefore, to make a more detailed ecological study of the region. For this purpose an excursion to Southern Sinai was arranged by the present authors in May 1956. After crossing the Suez Canal the group proceeded in a south-easterly direction in the foreshore plain of Western Sinai parallel to the gulf of Suez and at a considerable distance from it, till Abu Zeneima. The most important places traversed in that part of the route were Ayoun Musa Oasis, the delta of Wadi Sudr, Wadi Gharandal and Wadi Hammam Faraon. After Abu Zeneima the journey was continued southward till

Feiran Oasis, a distance of about 70 kilometers, and then eastward in Wadi Feiran till El Nabi Saleh. The route then turned southward again in Wadi El Sheikh till St. Katherine (Fig. 1).

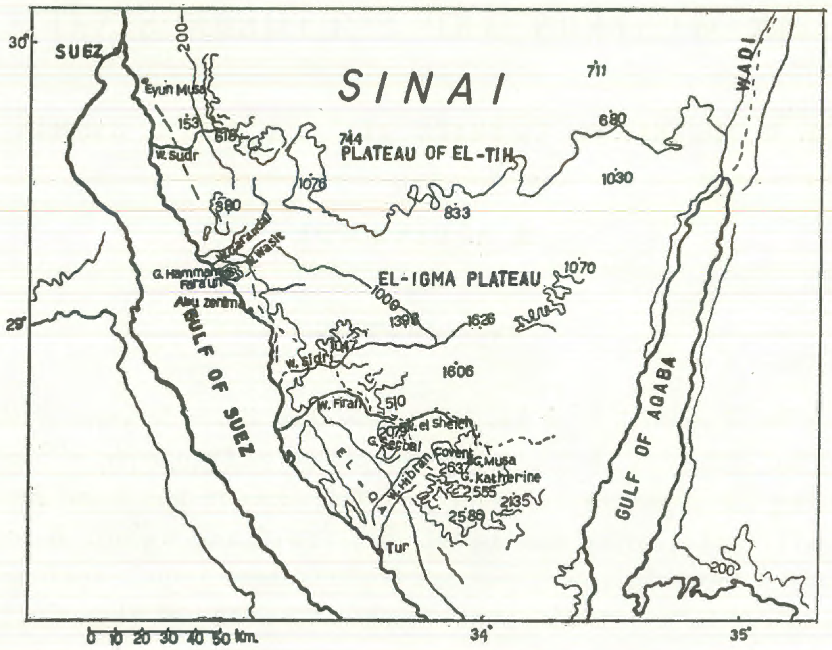


FIG. 1.

An ecological study of the various habitats and types of vegetation met with along the route was made. The present study is intended to be a basis for future, more intensive and extensive, studies.

The authors wish to thank Professor Dr. Vivi Täckholm for kind help in identifying the plants met with during the excursion.

GEOGRAPHICAL IMPORTANCE

The Peninsula of Sinai is a more or less triangular area of 61.000 sq. km., occupying the north-eastern corner of Egypt. It is separated from the Eastern Desert to the west by the Gulf of Suez and the Suez Canal, and

from Palestine to the east by the Gulf of Aqaba in the southern part. On the north it is bounded by the Mediterranean Sea and on the south by the Red Sea.

Sinai has the geographical importance of being the meeting place of Asia and Africa. For this reason its flora combines elements from these two continents. At the same time it is separated from phytogeographical regions of Egypt proper by such an effective barrier as the Gulf of Suez that it is nearly isolated and has a special flora of its own. In isolated mountains of Southern Sinai are represented relics of the flora of West and Central Asia.

TOPOGRAPHY AND LANDFORMS

The Mediterranean littoral of Sinai is low and sandy, with sand dunes extending several kilometers inland and forming a continuous series parallel to the sea. This flat, northern, belt belongs to the Mediterranean (Mp.) phytogeographical region of Egypt. The northern dunes of this belt are elongated, while at its southern edge the dunes are of the barkhan type.

South of the flat coastal belt the ground level gradually rises for a distance of about 250 kilometers into a limestone plateau, terminating in the great escarpment of El Tih. The Tih plateau slopes from heights of more than 1000 m down to the Mediterranean. In some places, e. g. in Gebel Egma, the escarpment even rises to heights of over 1500 m above sea level. The plateau is dissected by drainage channels, most of which drain to the Mediterranean. These channels are, as a rule, much shallower and more open than the wadis of the southern mountainous country. This middle part of the peninsula is, in reality, an extension of the Eastern Desert of Egypt, and belongs to the Isthmic Desert subregion (Di).

It is the southern part of the peninsula (South Sinai Stable Area according to Shata 1955 and 1956) that represents Sinai proper in the phytogeographical sense. It has an area of 20,000 sq. km., i. e., about one-third of the entire area of the peninsula, and represents a distinct phytogeographical region (S), rich in endemic species. South

of El Tih the character of the country abruptly changes, and gigantic rugged mountains, intersected by narrow valleys, appear. This mountainous country is separated from El Tih plateau to the north by a flat sandy plain, with scattered blocks of Nubian sandstone. The northern part of South Sinai is a broad belt of dark-coloured purplish or reddish sandstones extending across the peninsula from shore to shore. To the south of this belt there is a triangular mass of mountains, 7500 sq. km. in surface area formed of igneous and metamorphic rocks, chiefly granites. It is intensely dissected and rugged. The wadis become deeper and deeper and the igneous hills on either side become accordingly higher and higher as one proceeds southward.

In this triangular southern mass, the igneous complex has been relieved of its sandstone overburden, and so manifests the true characteristics of igneous mountain ranges. This group of granite mountains is divided into three clusters : Mount Serbal Pile to the west (2070 m), Mount Moses (2285 m) and Gebel Katherine (2641 m) group in the centre and Um Shomer (2586 m) in the south. These mounts are higher than any mountains in Egypt proper. The general level of the southern plateau is at an altitude of 730 to 1500 m above sea level, with several scattered high peaks. The valleys are long, winding and have a serpentine course. As in all igneous-rock districts they contain here and there little water springs round which small oases of palms grow.

There is a relatively broad coastal plain (foreshore province; Shata, 1955) extending in West Sinai from the Gulf of Suez to the great western Tih escarpment and its continuation southwards in the granite ranges of Southern Sinai. This plain is not uniform in breadth, being broader in its northern part till Gebel Hammam Faraon, than in the more southern parts. The northern division has an average breadth of 30 km. It is very gently undulating and locally dotted with low hills of limestone. The surface of the plain is largely covered with drift sand which, north of the latitude of Suez, forms parallel crescentic dunes (Barkhans). In more southern parts the coastal plain is composed of sandy marls and gypsum covered in some parts with gravels. Several wide and shallow wadis traverse the plain in that reach, being separated by low ridges.

Other places of the northern foreshore area, extending southward to Ayoun Musa, are subjected to inundation. In the dry season such places become covered with a thin mantle of white salt.

The foreshore plain of West Sinai is also crossed in its southern half by well defined ridges, such as G. Hammam Faraon and G. Araba, the summits of which are over 500 m above sea level. Opposite these ridges the coastal plain is very much reduced in width.

South of G. Hammam Faraon the coastal plain is made of a combination of two small plains : the northern one representing the deltas of Wadi Baba and Wadi Sidri, while the southern representing the delta of Wadi Feiran. The surface of these two plains is covered by igneous and limestone boulders, wadi gravels and alluvium. They are fed by an abundant water supply from their respective wadis and so support a relatively rich vegetation of *Acacia* trees and other desert bushes.

South of G. Araba the coastal plain is a part of Wadi El Qaa. This wadi varies in width from 3-4 km. near Ras Mohammed to a maximum of 36 km near El Tor. Wadi El Qaa is very poor in vegetation owing to its steepness and openness.

The hills forming the eastern boundary of the foreshore plain become progressively higher as one proceeds southward. The plateau of Southern Sinai drops by a number of steps to that plain. Along the Gulf of Aqaba, on the contrary, the mountains approach very close to the sea, and the coastal plain is relatively narrow.

According to Hassib (1950) there is a marginal strip of saline land along the Gulf of Suez in most parts of Southern Sinai, supporting halophytic vegetation. Eastward of that strip the ground rises to form a flat expanse of coastal plain. Further east the ground becomes gradually differentiated into broad shallow valleys alternating with broad low ridges. The ground then rises; the ridges become higher and the valleys become narrower and deeper, and support a richer vegetation.

WATER SUPPLY

The water supply to Sinai Peninsula is mainly derived from rain. Along the Mediterranean coast the rainfall is relatively abundant and

rain water is stored in the sand and can be raised to the surface by digging shallow wells. In the desert country of Middle Sinai the rain is scanty and the water supply is less abundant and more saline than in the Mediterranean Region.

In the southern, mountainous country the rainfall, though scanty in itself, is decidedly greater than in the deserts of Egypt proper. The rain-fed water sources are more abundant than in the more northern parts of the Peninsula. There is a broad catchment area. Water falling on the mountains runs over the slopes and collects in the narrow deep wadis where it forms perpetual streams and rivulets. Water is fresh in Southern Sinai and evaporation is slight. Rain storms sometimes burst upon the mountains in terrible floods, causing torrents which carry down boulders and pebbles. In a few cases such storms change a dry valley into a mighty river for some time. The excess water percolates and becomes stored underground in rock crevices. It can be obtained by digging wells or appears at the surface as springs or streams of fresh water. In this way it forms a permanent source of water supply.

The biggest collection of fresh water wells and streams is found near the monastries of St. Catherine and Feiran. Rain water, collecting in rock clefts, may sometimes form small pools of fresh water.

Another source of water supply is the snow which covers the summits of high mountains in winter. The snow mantle may reach a depth of one metre or more in some places, and may persist throughout the winter. As it melts with the advent of warm weather it runs down the mountain slopes and adds to the water resources of the valleys. Zohary (1935) believes that some of the higher mountains enjoy an annual precipitation of not less than 300 mm.

These big resources of fresh water have made possible the growth of rich wild vegetation in Southern Sinai, as well as the development of oases and *Tamarix* forests in many wadis. It has also made possible the cultivation of cereals, vegetables and fruit trees, especially round human settlements like the monastries.

CLIMATE

It is regretted that no regular meteorological records are available for the inland granite country of Southern Sinai. The information at hand about that part is only scanty and fragmentary. There are, however, regular records for two stations along the Gulf of Suez, namely, Suez and Tor. Along the Mediterranean coast there are regular records for El Arish, while for Middle Sinai there are records for Nekhl on El Tih.

For information about the climate of the inland part of Southern Sinai reference had to be made to the Meteorological Atlas of Egypt as well as to the fragmentary climatic data collected at St. Catherine Monastry.

In Table 1 are given the mean values of climatic factors for Suez. Tor and Nekhl.

TABLE 1

Climatic Conditions of Middle and Southern Sinai

Climatic factor	Stations		
	Suez	Tor	Nekhl
Mean Temperature (°C) :			
January	13.8	14.2	8.7
July	28.4	28.3	24.7
Mean for the year	21.7	22.2	17.8
Relative humidity (%) :			
January	68.0	58.0	—
July	62.0	62.0	—
Mean for the year	64.0	60.0	—
Rainfall (mm) :			
Total annual	21.0	13.0	26.0
No. of rainy days (1.0 mm)	4.5	2.3	6.2
Evaporation (Piche) ; mm/day :			
January	5.1	7.1	—
July	13.7	12.6	—
Mean for the year	9.3	9.4	—

Climatically, the part of Middle and Southern Sinai studied here can be divided into two main subdivisions :

1. The coastal Plain (West Sinai Foreshore Area).
2. The Central Mountainous Country.

The Coastal Plain :

Here the climate is primarily determined by two main factors : Latitude and maritime influence. Suez lies at the same latitude as Cairo. Consequently the mean annual temperature, as well as the winter and summer temperatures, are nearly the same in the two places, being only slightly higher in Suez than in Cairo. At Tor the temperatures are appreciably higher because of the effect of latitude.

The maritime effect in moderating air temperature is evident from the fact that in winter Suez and Tor are warmer than places in the Nile Valley more than 500 km. further south. In summer (July) Tor is nearly at the same temperature as Cairo, 300 km. to the north[1]. In consequence the annual range of monthly mean temperature is narrower in places along the Gulf of Suez than in others at the same latitude in the Nile Valley. The winter is alway warmer along the coast than inland.

As far as the relative humidity is concerned the maritime effect is evident from the fact that the mean annual relative humidity is higher in places along the Gulf of Suez than in others at the same latitude in the desert and Nile Valley. Furthermore, the annual range of relative humidity is narrower in coastal stations than in inland ones. The relative humidity along the coast does not usually fall down during the summer to such low levels as those observed in more inland places. In other words the summer is always fairly humid. The effect of latitude on relative humidity is evident from the fact that Tor is appreciably drier than Suez, the annual mean relative humidity in the former being 60 %, as compared with 64 % in the latter. The maritime effect on relative humidity is more evident at Tor than at Suez. This may be referred to the fact that at Tor the Gulf of Suez is much broader than at Suez which lies at the narrow northern extremity of that gulf.

[1] Meteorological Atlas of Egypt (1931).

The latitude of a place is of prime importance in determining its rainfall. The rainfall of Tor is only 13 mm per annum as compared to 21 mm at Suez. This shows how dry the foreshore area of West Sinai is. The number of rainy days with rainfall exceeding 1 mm is less than 5 days in Suez and 3 days at Tor. However, at Tor the rainfall is much higher than in places at the same latitude in Upper Egypt.

Evaporation is active along the Gulf of Suez, the annual mean being nearly double as much as in Cairo.

The direction of the wind that blows on Suez is mainly from the north in all seasons of the year. Winds from west and south are very rare, and only prevail in winter in small proportions. The winds blowing on Tor and the whole Gulf of Suez are mainly from the northwest in all seasons of the year. However in winter there is as much, or even slightly more, wind blowing from the north as that blowing from the northwest. That northwesterly current is strongly developed on account of the hills bordering the gulf. It is a well known fact that the local topography has a strong effect in modifying the wind direction and strength. The relative values of the mean wind force (Scale 0-12) are 2.2 for Suez and 2.7 for Tor, which are quite moderate.

The Central Mountainous Country :

The climate of this subdivision is determined primarily by the altitude, the effect of which masks that of the latitude. Nekhl lies at the same latitude as Helwan, namely, Lat. 29° 54′ N. Yet the annual mean temperature of Nekhl is 17.8° C while that of Helwan is 20.8° C. In other words Nekhl is 3° C cooler than Helwan. This is referred to the fact that Nekhl is much higher in level, being situated on El Tih Plateau at an altitude of 400 m above sea level while Helwan is situated at an altitude of only 116 m.

Like all inland stations there is a wide difference in temperature between summer and winter. August is the hottest month, with a mean temperature of 25.4° C, and January is the coldest month, having a temperature of 8.7° C. The annual range of monthly mean temperature is, therefore, 16.7° C, which is wider than in any of the two coastal stations along

the Gulf of Suez. Throughout the winter the mean monthly temperature is below 10° C in the mountainous country of Central Sinai. The greater the altitude the lower the winter temperature and the longer the duration of cold weather. Absolute minima of less than -6° C are of frequent occurrence between November and March in that part of the Peninsula, but nowhere else in Egypt. The summer temperature is lower, not only than in any of the inland stations in Egypt proper but also than any of the coastel stations along the Gulf of Suez. Obviously the temperatures in all seasons must be much lower on the high mountains of South Sinai, which exceed 2000 m in height than at Nekhl, presented in the table.

Not only the annual range but also the diurnal range of temperature is very wide in the mountainous region of Sinai. In contrast to the effect of the sea in moderating temperature, the effect of the high mountains of Sinai is to make the climate continental and to augment the differences between day and night temperatures. The mean diurnal range varies from 16° C in winter and autumn to 20° C in spring and summer. This range is even wider than in the midst of the Lybian desert south of the latitude of Aswan.

With regard to the relative humidity reference to the Meteorological Atlas will show that the mountainous southern part of Sinai is one of the driest parts of Egypt. In all seasons of the year the relative humidity is below 40 %. At 2 p.m. it falls down below 20 % except in winter time when it is maintained between 20 and 30 %. The mountains of Sinai are comparable in their low relative humidity with the deserts of Egypt proper.

The rainfall is more closely correlated with the latitude than any other climatic factor. That is why at Nekhl the total annual rainfall is nearly the same as at Cairo and Suez, being about 27 mm/annum. The number of rainy days is also nearly the same as in Cairo, being about 6 days every year. At St. Catherine the rainfall is much higher than at Nekhl because of its higher altitude, being 60 mm or more. The rainfall at Themed is 39 mm. If to the rainfall is added the snowfall the water supply to the mountain range must be enormous.

HABITATS AND VEGETATION

The flora of Sinai is very rich, amounting, according to Hassib (1951) to no less than 527 species of which 134 are not found in any other place in Egypt. There is a number of different ecosystems the vegetation of which is denser and the plants are larger and more crowded than in the corresponding ecosystems in the Egyptian deserts. In contrast to the desolate barren mountains of the Eastern Desert the mountains of Southern Sinai bear plants at all altitudes from base to summit. There are only few species of high trees, the majority of plants are therophytes and hemicryptophytes. There is also a considerable number of Nanophanerophytes. *Tamarix* forests are occasionally met with. Different species are not isolated but usually grouped in associations, which in long wadis e. g. Wadi Feiran, pass gradually from one association to the other.

The following ecosystems were recognised by the present authors in Western and Southern Sinai.

A. — PLAINS

These mainly belong to the Gulf of Suez foreshore strip and to the broad wadi endings crossing that strip. They are open sandy areas with uneven relief, extending the whole way between Suez and Abu Zeneima, a distance of about 120 km. The soil in this habitat is deep and sandy. It is covered with gravel and little stones in some parts. The density of the vegetation depends upon the relief, being denser in depressions than in elevated parts. In most places the plant cover does not exceed 10 %. In flat parts where the scanty rain is distributed evenly without being accumulated in depressions by runoff, e. g., at kilos 25, 54 and 60 from Suez, the plant cover is even smaller and the vegetation is very poor.

The type of vegetation along Suez-Abu Zeneima Road is very similar to that along Cairo-Suez Road. In both districts *Haloxylon salicornicum*

is the dominant species. Associated with it are the following species : *Zilla spinosa, Retama raetam, Hyoscyamus muticus, Zygophyllum coccineum, Z. simplex* and *Fagonia* spp.

In areas with high salt and water content there is local abundance of either *Zygophyllum album* or *Tamarix mannifera.*

Not infrequently patches of land are met with, especially in depressions, covered with a cracking crust of water-borne silt. On such patches communities of *Zygophyllum coccineum* and/or *Z. simplex* are supported.

In some parts *Haloxylon* forms more or less pure associations. Being a sand binder this species forms little hillocks. In places between Ayoun Musa and Ras Sudr *Tamarix mannifera* is found, and the trees reach considerable height. This species is also a sand binder, and so forms baby dunes. *Hyoscyamus muticus* was also met with in this part of the plain.

South of Wadi Asal the relief becomes uneven. The ground surface undulates and sand dunes begin to appear. In some of the furrows are found groves of *Tamarix mannifera,* sometimes associated with date palm. In that reach vegetation becomes denser and the plant cover gradually increases. The eastern hills come nearer and nearer to the sea until the coastal plain near Abu Zeneima becomes reduced to a narrow strip.

The following species were met with for some distance south of Wadi Asal : *Halogeton alopecuroides, Gymnocarpus decandrum, Ephedra alata* and *Zygophyllum dumosum.* The last-named plant is a woody species with winged fruits.

Between Wadi Asal and Abu Zeneima the following plants occur : *Retama raetam, Reaumuria hirtella, Diplotaxis harra, Zygophyllum simplex, Reichardia orientalis, Nitraria retusa, Acacia* sp. and *Phoenix dactylifera.*

The habitat of the plains is less favourable for plant growth than any other habitat in Southern Sinai for the following reasons :

1. Low water supply because of scanty rainfall and lack or slight accumulation of water in furrows and depressions by runoff owing to relative evenness of the relief.

2. Openness and direct exposure to atmospheric evaporating factors.

3. Exposure to factors (mainly wind) causing degradation and erosion of the soil.

4. Uprooting of plants by wind and burial of others under wind-drifted sand, espacially during the Khamseen period.

In the following table (Table 2) are given the results of analysis of soil from the plains of West Sinai foreshore, north of Ayoun Musa. The soil supported a pure association of *Haloxylon salicornicum.* The place was representative of the surrounding plain. The soil surface was covered with stones and pebbles and the sample was collected from a depth of 10-20 cm.

TABLE 2

Analysis of Soil from the Foreshore Plains of West Sinai

			Granulometric Analysis	
			mm	%
Water-saturation capacity (%)	=	17.3		
Water retained at air dryness (%)	=	0.47	> 1.41	= 8.2
Water-soluble salts (%)	=	0.68	1.41-0.30	= 46.3
Concentration of soil solution (p.p.m)	=	1350	0.30-0.15	= 32.2
Conductivity (millimhos)	=	2210	0.15-0.07	= 10.1
Carbonate content (%)	=	11.69	< 0.07	= 3.0
Organic matter (%)	=	0.29		
*p*H	=	7.6		

The soil is sandy and coarse-grained. The greater part of the sample has a particle size exceeding 0.15 mm. The carbonate content is high and the soil solution is rather concentrated. As in deserts and similar habitats with a small plant cover, the content of organic matter in the soils of the foreshore plains is very small. The soil reaction is weakly alkaline.

B. — WADIS

Wadis traversing the coastal plains between Suez and Abu Zeneima are just shallow and ill-defined furrows. As one proceeds southward the wadis become progressively deeper and well-defined. Thus the mountainous southern part of Sinai is dissected by a complicated system

of deep wadis, some of which reach a considerable length, e. g., Wadi Feiran and Wadi Gharandal. Other wadis are shorter, narrower and steeper, and represent tributaries of the main wadis, e. g., Wadi El-Arbaeen, Wadi El Raha and Wadi El Sheikh.

In the following pages is given a description of the wadis visited by the authors and their vegetations.

1. *Wadi Feiran :*

This is the longest of all wadis in Southern Sinai. It rises from the high mountains surrounding the monastery of St. Catherine, at a height of 2500 m or so above sea level. It descends steeply to the north, then turns to the west till it pours into the Gulf of Suez at about Lat. 28° 40′ N.

The study of this and similar long wadis which traverse different types of country is of great interest. Owing to differences in altitude, slope, geomorphology, depth and breadth of the various parts, these parts represent different types of plant habitat. On passing from the upper to the lower reaches of Wadi Feiran one comes across a number of different plant associations. The density of vegetation and vigour of plants decreases progressively from south to north.

The continuation of Wadi Feiran southward is called Wadi El Sheikh. Between El Nabi Harun near St. Catherine Monastery and El Nabi Saleh there is an association of *Zilla spinosa* with *Retama raetam* and *Fagonia arabica* as subordinates. The total plant cover is 20-30 %. Wadi El Sheikh is relatively flat and broad. On its bed there are no such big boulders as those found in steep wadis, which are usually narrow and deep. On the surface there are gravels and little stones.

At El Nabi Saleh *Artemisia judaica* begins to appear. At first it is associated with *Zilla* but later increases as one proceeds northward till it dominates. In some localities, however, it exchanges dominance with *Zilla*.

Further down the wadi *Zilla* begins to disappear while *Achillea fragrantissima* appears. An association of these two species continues to cover the wadi bed for some considerable distance.

In this southern part of the wadi the sides are made of granite rock. Gradually the granite disappears and sedimentary rock takes its place. The vegetation changes accordingly, and the changes are easily noticeable. *Haloxylon salicornicum* begins to appear, being associated with *Zilla spinosa, Artemisia judaica* and *Achillea fragrantissima.* A little further northwest *Tamarix mannifera* (Photo 1) appears and even dominates in some localities, forming a sort of forest. Associated with *Tamarix* is *Retama raetam.* After some distance *Tamarix* disappears while *Artemisia judaica* and *Zilla spinosa* reappear, covering alluvial patches of the wadi bed.

Associations met with further west are dominated by *Haloxylon* and *Retama,* with occasional *Zilla* in some places. Another *Tamarix* forest reappears with the approach of Feiran oasis.

It is remarkable that only in some parts of the wadi the plant cover decreases below 10 %. In most parts it is higher than that.

Westward of Feiran Oasis there is a grove of *Acacia* trees. The rocks forming the sides of the valley immediately west of the oasis are granite. The wadi in that part is deep and narrow, and the water supply is plentiful. Consequently the vegetation is dense. The plant cover is large and the tree elements are abundant.

Beyond the *Acacia* community *Haloxylon* dominates for a long distance, with a few scattered *Acacia* trees. Subordinate species in that part of the wadi are *Aerva persica* (= *A. tomentosa*), *Ochradenus baccatus, Hyoscyamus muticus* and *Convolvulus hystrix.* In fact *Haloxylon* is by far the most common species in most parts of Wadi Feiran downstream Wadi El Sheikh. Like *Haloxylon* and *Retama, Ochradenus* is a sand binder and collects sand at its base.

A considerable distance northwest of Feiran Monastry the valley becomes shallow and broad, and the rocks become calcareous. Near its mouth, about 10 kilometers from the Gulf of Suez, coastal sand dunes begin to appear, and the vegetation takes on another aspect. *Nitraria retuse* appears, but still *Haloxylon* dominates. The mouth of the wadi is a flat plain, with scattered patches of salt marshy ground supporting halophytic vegetation.

2. *Wadi Gharandal :*

This wadi (Map, Fig. 1) crosses the foreshore plain at about 90 km south of Suez and 30 km north of Abu Zeneima. Its soil is sedimentary and calcareous, with drifted air-borne sand at the surface. Near the entrance to the western part of the wadi from the main road is found an association of *Tamarix articulata*. The total plant cover is 30-40 %. Sand dunes are abundant on the wadi bed. They are low and solitary, being formed from sand drift trapped by sand-binding plants. Most of them are covered with *Tamarix*, but some are also covered with *Retama* or *Nitraria*. The sides of the wadi in this part of its course are relatively low and the wadi itself is broad.

Wadi Gharandal enjoys an adequate water supply. If wells are dug in its bed it is possible that limited cultivations can be supported.

At the bottom of Wadi Gharandal, a few kilometers from its entrance at the main road, is found a spring overflowing the surface of the ground and supporting salt march vegetation. There is also a grove of *Tamarix* trees at a higher level surrounding a well.

3. *Wadi leading to G. Hammam Faraon :*

This wadi crosses the foreshore plain at about 20 km north of Abu Zeneima. At its western entrance from the main road the rocky sides are represented by consolidated limestones of little height supporting *Ephedra alata*. *Haloxylon salicornicum* is also found, but on the wadi bed. The two species were green and flourishing in that warm part of the year and *Ephedra* was grazed by camels.

For a distance of about 2 km to the west of the main road the wadi is flat, shallow and irregular in width. The soil is calcareous and *Haloxylon* dominates, being associated with *Ephedra alata*, and in some parts also with *Zygophyllum dumosum*. These two associates are mainly found on terraces along the sides of the wadi, while *Haloxylon* is found on the wadi bed. The terraces of the rocky sides of the wadi are covered in many parts by wind-drifted sand. *Ochradenus baccatus* and *Retama raetam* are rare in this community. The former is heavily grazed.

In some parts of the wadi the *Haloxylon* association disappears and becomes replaced by an *Ephedra* association. In other parts the community is equally dominated by these two species, in association with the following subordinates : *Hyoscyamus muticus, Zygophyllum dumosum, Z. simplex* and *Heliotropium luteum.*

At the end of the first two kilometers the wadi turns sharply to the left, towards its mouth in the coastal plain. The latter is very narrow in that part of its course owing to the presence of G. Hammam Faraon very close to the sea. At the turning point of the wadi is found a high, wall-like, cliff of light-coloured sedimentary rock, with distinct stratification.

As one comes nearer and nearer to the sea isolated sand dunes of progressively increasing height begin to appear, being covered with dune plants. In the narrow coastal plain are found scattered salt marshes supporting halophytic vegetation.

Soil was collected for analysis from the deposits underneath *Ephedra alata,* near the entrance of the wadi from a depth of 20-25 cm. The soil is coarse sand mixed with small gravels. In Table 3 are given the results of soil analysis.

TABLE 3

Analysis of Soil from Wadi Hammam Faraon

		Granulometric Analysis	
		mm	%
Water-saturation capacity (%)	= 24.8		
Water retained at air dryness (%)	= 1.51	> 1.41	= 40.7
Water-soluble salts (%)	= 1.51	1.41-0.030	= 22.8
Concentration of soil solution (p.p.m)	= 1400	0.30-0.15	= 22.6
Conductivity (millimhos)	= 220	0.15-0.07	= 11.9
Carbonate content (%)	= 23.02	< 0.07	= 2.0
Organic matter (%)	= 0.0		
*p*H	= 7.7		

The soil is coarse-grained. Two-fifths of its weight has a particle size exceeding 1.41 mm diameter, while 45 % fall in the category of

1.41—0.15 mm. Owing to its coarse texture the soil has a low saturation capacity and a low capacity for water retention at air dryness. Like all sandy soils of the low lands the salinity is fairly high. There is no decaying organic matter in the soil on account of the sparse vegetation. The carbonate content is about one quarter of the total weight of the soil since the prevailing rock is limestone. The soil being light and sandy, its reaction is fairly alkaline.

4. *Wadi El Raha* :

This wadi is very close to St. Catherine Monastry. It is a short broad valley, ending blindly within the granite mass of Southern Sinai. The valley is broadest at the mouth, being about 400 m in breadth, but narrows out gradually as one proceeds westward. It is relatively flat, being only slightly lower at the sides than in the middle. The valley slopes down very gently, and that is perhaps why its bed is not covered by such boulders and huge rocks as those found in Wadi El Arbaeen. In Wadi El Raha these boulders are only found along the sides. The wadi bed is covered with little stones and granite fragments, mixed with fine sedimentary soil. The soil is deep and the proportion of fine material increases with depth. Although the soil is dry at the surface it is fairly moist at a depth of 30 cm, and its water content increases regularly with depth. The valley is bounded by high mountains on all sides.

At the mouth of Wadi El Raha (Photo 2) the total plant cover is 20-30 % and the floristic composition of the vegetation is as follows :

Zilla spinosa	d
Achillea fragrantissima	o
Peganum harmala	r
Fagonia mollis	r
Artemisia herba-alba	r
Diplotaxis harra	v.r

In Table 4 is presented the analysis of soil from the bed of Wadi El Raha supporting *Zilla spinosa* association at a depth of 40-50 cm.

Table 4

Analysis of Soil Supporting *Zilla spinosa* Association in Wadi El Raha

		Granulometric Analysis	
		mm	%
Saturation capacity (%)	= 20.9		
Water retained at air dryness (%)	= 0.62		
Water content (%)	= 2.58	> 1.41	= 38.2
Water-soluble salts (%)	= 0.04	1.41-0.30	= 51.9
Concentration of soil solution (p.p.m)	= 80	0.30-0.15	= 5.7
Conductivity (millimhos)	= 150	0.15-0.07	= 3.0
Carbonate content (%)	= 0.16	< 0.07	= 1.2
Organic matter (%)	= 0.22		
*p*H	= 8.0		

The soil of this southern wadi of the granite block resembles that of the northern sandy wadis and plains in its coarse texture and low water capacities. About 90 % by weight of the soil is made of granules exceeding 0.30 mm in diameter. The granules are largely granite fragments. The differences from northern soils are, however, more striking. The salinity and carbonate content are much lower in the granite soil of Wadi El Raha than in the sandy limestone soils of the more northern habitats. The soil is fairly alkaline and the organic matter content is as low as in the sandy soils of northern habitats.

The low salinity of soils and waters of the granite southern block may be referred to the stability and sparse erosion of the granite. Soil is shallow and there is no dissolution of minerals by water passing through it.

The results of the analysis also reveal that the soil at the working zone of the roots contains a fair amount of available water.

As already mentioned the sides of the wadi bed at the mouth are lower in level than the middle. Water running off the surrounding hills collects at the sides of the bed. The runoff water washes away the surface soil together with the covering vegetation and germules, with the result that the plant cover decreases at the sides to about 10 %. However,

the condition of growth is excellent and the plants are more vigorous than in a desert wadi.

Two stands were examined at the sides of the wadi bed near the mouth. The structure of the vegetation in these stands is as follows :

	Stand 1	Stand 2
Zilla spinosa	d	d
Peganum harmala	cod	a
Gomphocarpus sinaicus	r	r
Pulicaria crispa	r	—
Achillea fragrantissima	r	c
Reseda pruinosa	r	v.r.
Fagonia mollis	—	r

Soil was collected from the side of the wadi bed at a depth of 40-50 cm and analysed. The following results were obtained.

TABLE 5

Analysis of Soil from the Sides of the Bed of Wadi El Raha

		Granulometric Analysis	
		mm	%
Saturation capacity (%)	= 24.9		
Water retained at air dryness (%)	= 0.53	> 1.41	= 44.0
Water content (%)	= 2.93	1.41-0.30	= 49.0
Water-soluble salts (%)	= 0.05	0.30-0.15	= 3.4
Concentration of soil solution (p.p.m)	= 100	0.15-0.07	= 2.5
Conductivity (millimhos)	= 190	< 0.07	= 1.1
Carbonate content (%)	= 0.54		
Organic matter (%)	= 0.05		
*p*H	= 8.0		

It is clear that the soil is very similar on the side of the wadi bed to that in the middle, except for a somewhat higher water content on the side.

5. *Wadi El Arbaeen :*

This is a narrow steep valley having its mouth opposite to that of Wadi El Raha. On its bed are scattered boulders and big stones. There are successive broad terraces reducing the wadi bed in many parts to a deep narrow channel flooded by spring water. Springs of fresh water either flow in narrow shallow channels or from little ponds in the rock at the sides of the wadi bed. Round these springs grow hygrophytic shade plants as well as aquatic and marsh plants. In deep parts the spring water is abundant and overflows a considerable area, being conducted in runnels and watercourses. When the water supply is so abundant it allows for the development of oases.

The soil of Wadi El Arbaeen is made of big stones and coarse fragments, together with fine material produced by the disintegration of rock. The proportion of stones and coarse fragments is bigger in the soils of Wadi El Arbaeen than in any other habitat in Sinai. The surface of the wadi bed is very rough. The plants are scattered among the rocks and spring out between them.

Wadi El Arbaeen has a very rich flora. The following is a list of the species collected from the bed of that wadi during the excursion :

Lactuca orientalis	*Sonchus oleraceous*
Pulicaria arabica	*Melilotus indicus*
* *Asperugo procumbens*	*Anchusa aegyptiaca*
Veronica anagallis	*Sysimbrium irio*
Ammi majus	* *Hypericum sinaicum*
Euphorbia peplus	*Onopordon ambiguum*
Chenopodium murale	*Brachypodium distachyum*
Plantago ciliata	*Hordeum murinum*
Carduus pycnocephalus	
* *Verbascum schimperianum*	

A glance at the above list will show that most of the plants are mesophytes or characteristic of moist habitats, e. g., *Sonchus, Melilotus, Sysimbrium,*

Note : Species indicated with (*) are found only in Southern Sinai.

Chenopodium murale, Euphorbia peplus, etc. A number of the species are more common in the Mediterranean region and Nile Valley than in the desert, e.g., *Plantago ciliata, Ammi majus, Carduus pycnocephalus, Anchusa aegyptiaca* and *Veronica anagallis*.

Asperugo procumbens, Hypericum sinaicum and *Verbascum schimperianum* are restricted to the mountains of Sinai. But true perennial xerophytes characteristic of the dry deserts are not represented in Wadi El Arbaeen except near the mouth where the conditions are drier and similar to those at the mouth of Wadi El Raha.

Thus in addition to the above list an association of *Peganum harmala* and *Zilla spinosa* was found at the mouth of Wadi El Arbaeen. The plant cover was about 10 % and the floristic composition of the association was as follows :

Peganum harmala	d
Zilla spinosa	cod
Stachys aegyptiaca	c
Achillea fragrantissima	c
* *Alkanna orientalis*	r
Artemisia judaica	r
* *Phlomis aurea*	r
Fagonia mollis	r
Ballota undulata	r
Lavandula coronopifolia	r
* *Origanum maru v. sinaicum*	r
Teucrium polium	r

Although the characteristic species of this community are true perennial xerophytes very common in Egyptian deserts yet they are much more vigorous in this habitat than in the desert regions.

In Table 6 are given the results of analysis of soil from the mouth of Wadi El Arbaeen supporting the above association. The soil was collected from a depth of 25-30 cm. The surface soil above that depth is very coarse and made of granite rock fragments of various shapes and sizes.

TABLE 6

Analysis of Soil Supporting *Peganum* Association at the Mouth of Wadi El Arbaeen

			Granulometric Analysis		
			mm		%
Saturation capacity (%)	=	17.2			
Water retained at air dryness (%)	=	0.51			
Water Content (%)	=	1.46	> 1.41	=	35.9
Water-soluble salts (%)	=	0.04	1.41-0.30	=	48.2
Concentration of soil solution (p.p.m)	=	80	0.30-0.15	=	6.8
Conductivity (millimhos)	=	150	0.15-0.07	=	3.7
Carbonate content (%)	=	0.69	< 0.07	=	4.4
Organic matter (%)	=	0.24			
*p*H	=	8.1			

It is clear from the above results that the soil in this open part of Wadi El Arbaeen has nearly the same composition as that near the mouth of Wadi El Raha. Rock fragments and coarse granite particles cover the soil to a considerable depth in Wadi El Arbaeen. Thus at a depth of 25-30 cm the percentage of granules with diameter exceeding 0.30 mm was about 85 % of the total weight of the soil. Because of that coarse texture the saturation capacity and the water retained at air dryness are very low.

As in Wadi El Raha soil, and all soils of the granite mountains, the salinity and carbonate content are very low. The organic matter content is also low and the soil reaction is alkaline. There is a small amount of available water in the working zone of the roots to be used by the plants.

Communities of aquatic and marsh plants as well as oases which will be discussed later, are also very common in Wadi Arbaeen round the springs.

6. *Farsh El Gebel* :

About midway to the summit of Gebel Musa there is a broad flat area named Farsh El Gebel, in which springs and fresh water streams are

found. At one side there is a runnel sloping down steeply towards the « Farsh » and having a thick layer of silt at the surface superposed on the rocky substratum. On that alluvial soil grows a community of *Thymus decussatus* and *Artemisia herba-alba*. The total plant cover is very high, amounting to 70 % in the densest, upper, parts but decreasing to 50 % towards the foot of the slope and further to 40 % in the flat, lowermost, part at the « Farsh ».

The structure of the vegetation in the runnel was as follows :

Thymus decussatus	d
Artemisia herba-alba	cod
Phlomis aurea	a
Pyrethrum santolinoides	c
Teucrium polium	r
Varthemia montana	r
Stipa parviflora	v.r.
Scirpus holoschoenus	v.r.

In the flat part of Farsh El Gebel the vegetation was poorer than in the runnel, and the total cover did not exceed 40 %. This may be referred to the more deficient water supply in the flat part, rain water being evenly distributed over the whole area while accumulating by runoff in the runnel. The structure of vegetation in the flat part was as follows :

* *Aristida coerulescens*	d
Artemisia judaica	a
Phlomis aurea	c
Pyrethrum santolinoides	c

Soil was collected from three spots : (a) the middle of the runnel where the soil was made of thick alluvial deposits and the total plant cover was 70 % ; (b) the deep alluvium deposited on the surface of the flat « Farsh » near the spring ; and (c) the lower end of the runnel where the alluvial layer has disappeared and the plant cover has decreased to 40 %. The samples were collected from a depth of 10-20 cm.

In Table 7 are given the results of soil analysis :

TABLE 7

Analysis of « Farsh El Gebel » Soils

	Middle of runnel	Clay deposit near the spring	Rocky soil of the flat part
Saturation capacity (%)	44.0	43.3	22.6
Water retained at air dryness (%)	—	22.22	0.29
Water content (%)	6.95	42.46	—
Salinity (%)	0.12	0.22	0.08
Concentration of soil solution (p.p.m)	240	440	150
Conductivity (millimhos)	400	720	260
Carbonates (%)	2.57	3.49	1.16
Organic matter (%)	6.12	3.57	0.34
*p*H	7.8	7.8	7.6

Granulometric Analysis

mm		%	%
> 1.41	=	30.4	43.0
1.41-0.31	=	38.5	45.5
0.31-0.15	=	8.6	4.7
0.15-0.07	=	6.5	3.6
< 0.07	=	10.0	3.2

It is clear that the alluvial soils of Farsh El Gebel provide a habitat more favourable to plant growth than any other habitat in Sinai. This, in addition to the abundant water supply, are sufficient to explain why the vegetation is densest and most luxurient in that locality. The water saturation capacity in the alluvial soils is relatively very high. This is in part due to the higher proportion of fine-grained material and in part to the higher content of organic matter. A high proportion of fine particles enriches the soil in mineral nutrients, while organic matter improves the physical properties of the soil and increases its capacity for water retention.

The soil reaction is slightly alkaline, being less so than the soils of the wadi beds. The soil near the spring in almost fully saturated while

in the middle of the runnel it is at optinum water content in the working depth of the roots. The carbonate content is low in itself, though relatively higher than that of soils of the granite mountains of Southern Sinai.

C. — MOUNTAINS AND ROCKY RIDGES

There is a lot of different species of rock plants, found in the southern granite mountains as well as in the more northern sandstone and limestone ridges. They grow on the rocky sides of valleys, in gulleys, (photo 3) terraces and plateau. They are also found on boulders and big rocks of southern valleys, e. g., Wadi El Arbaeen.

The rock habitat is unfavourable to plant growth on account of increased resistance to root penetration, decreased depth of soil and deficient water content. For this reason it is only a special type of plants, the chasmophytes, that can tolerate the adverse conditions of this habitat.

Some of the rock plants are firmly attached to the smooth surface of the rock by means of hook-like roots, e. g., *Galium sinaicum* and *Origanum maru*. Other plants are found in rock crevices which, though narrow, are sometimes very deep. Soil and plant litter accumulate in these crevices, retaining water and forming a fertile substratum through which plant roots penetrate. Deep crevices support several species of shrubs and trees, e. g., *Ephedra alata, Moringa aptera, Ficus pseudosycamorus, Capparis cartilaginia* and *Cupressus sempervirens*. Rock plants may also be found in surface notches and depressions of various sizes in which soil and decaying organic matter are retained. Another rocky medium is the terraces and flat plateau on the surface of which a small depth of soil is deposited.

The following rocky habitats were studied :

1. *The Rocky Sides of Wadi El Raha :*

Two stands were examined on the northern rocky slopes of Wadi El Raha at the mouth. The floristic composition of these stands was as follows :

Stand I		Stand II	
* *Alkanna orientalis*	d	*Varthemia montana*	d
Achillea fragrantissima	a	*Achillea fragrantissima*	c
Stachys aegyptiaca	a	*Stachys aegyptiaca*	c
Varthemia montana	r	*Cynodon dactylon*	c
Zilla spinosa	r	*Lavandula coronopifolia*	c
		Stipa tortilis	r
		* *Alkanna orientalis*	r

The plants grew at heights of 4-10 m from the bed level of the wadi. They were rooted in crevices of the granite rock, and were widely spaced. The mountain sloped gently. *Zilla* tended to decrease progressively with height upon the slope while *Varthemia* and *Stachys* increased.

Soil supporting the above associations was collected from the crevices at a depth of 40-50 cm and analysed. It was made of rock fragments mixed with a small proportion of fine particles. The results are given in Table 8 :

TABLE 8

Analysis of Soil from the Rocky Sides of Wadi El Raha

		Granulometric Analysis	
		mm	%
Saturation capacity (%)	= 23.0		
Water retained at air dryness (%)	= 1.02	> 1.41	= 21.6
Water-soluble salts (%)	= 0.11	1.41-0.30	= 39.4
Concentration of soil solution (p.p.m)	= 220	0.30-0.15	= 12.7
Conductivity (millimhos)	= 360	0.15-0.07	= 8.0
Carbonate content (%)	= 0.62	< 0.07	= 17.6
Organic matter (%)	= 0.85		
*p*H	= 8		

The analysis shows that there is a higher proportion of fine particles and organic matter in the soils of rock crevices than in those of the wadi bed. The salinity is also a little higher but the soil reaction is the same, being slightly alkaline.

A gulley at a higher level, also on the northern side of Wadi El Raha, was examined. It is 4-5 m broad and is representative of many similar

gulleys found in the mountains of Southern Sinai. There were boulders covering the surface of the gulley bed to which *Galium sinaicum* was sticking firmly. On the flat soil of the gulley bed, between the boulders, grew the following species : *Lavandula coronopifolia, Zilla spinosa, Teucrium polium, Ephedra alata, Fagonia mollis* and *Gomphocarpus sinaicus*. In the fissures of the boulders were found the following species :

Varthemia montana	*Artemisia judaica*
Alkanna orientalis	*Parietaria alsinifolia*
Stachys aegyptiaca	*Scirpus holoschoenus*
Teucrium polium	*Capparis spinosa*
Ballota undulata	*Fagonia mollis*
Artemisia herba-alba	

Most of the above species were also found on the two sides of the gulley at various levels. In addition there were *Cynodon dactylon, Capparis cartilaginia, Pulicaria arabica* and *Scirpus holoschoenus*. The presence of the last-named plant is indicative of high humidity of the habitat.

Soil from one of the fissures of the above gulley supporting *Varthemia montana* was analysed. The results are presented in Table 9.

TABLE 9

Analysis of Soil from a Rock Fissure in one of the Gulleys of Wadi El Arbaeen

		Granulometric Analysis mm	%
Saturation capacity (%)	= 41.3		
Water retained at air dryness (%)	= 1.85	> 1.41	= 37.4
Water-soluble salts (%)	= 0.11	1.41-0.30	= 37.1
Concentration of soil solution (p.p.m)	= 220	0.30-0.15	= 7.6
Conductivity (millimhos)	= 400	0.15-0.07	= 5.4
Carbonate content (%)	= 0.72	< 0.07	= 7.6
Organic matter (%)	= 4.76		
*p*H	= 7.7		

The saturation and water-retaining capacities of this sample are higher than those of the previous one (Table 8), although the proportion of

fine-grained soil is higher in the latter than in the former. Explanation of this discrepancy is that the content of organic matter is very high in the soil of the gulley, being five times as much as in the rock crevices at the mouth of the wadi. The high organic content is also responsible for the less alkaline reaction of the gulley soil.

2. *Mountains near St. Catherine Monastry :*

The monastry of St. Catherine lies at the bottom of a narrow flat depression surrounded by steep high mountains on all except the western side leading to Prophet Aron's tomb (El Nabi Harun) at the meeting point of Wadis El Raha, El Arbaeen and El Sheikh. In the mountains surrounding the monastry the following plants are found :

Peganum harmala	* *Alkanna orientalis*
Ballota undulata	* *Galium sinaicum*
* *Solanum nigrum v. villosum*	*Achillea fragrantissima*
Stachys aegyptiaca	*Zilla spinosa*
Fagonia mollis	*Andrachne aspra*
Varthemia montana	*Caylusia canescens*
Heliotropium arbainensis	*Campanula* sp.
Scrophularia sp.	*Ficus pseudosycamorus*
Ficus carica v. *rupestris*	*Fagonia arabica*
* *Phlomis aurea* (Photo 4)	*Teucrium polium*
Gomphocarpus sinaicus	*Iphiona mucronata*
Tricholaena teneriffae	*Echinops glaberrimus*
Pityranthus tortuosus	*Launaea spinosa*
Hyparrhenia hirta	*Helianthemum ventosum*
Orobanche sp.	*Matthiola livida*
Pulicaria crispa	

Those plants are found at different levels on the mountain slopes and the more xerophytic ones tend to be more abundant in the lower levels.

3. *Gebel Musa :*

This mountain is located southeast of St. Catherine Monastry. The northern (windward) slope of this mountain is richer in vegetation than

the southern slope of the opposite mountain, on the other side of the monastry. On that slope there are many species of shrubs and trees rooted in the crevices of the rock, e. g., *Ficus pseudosycamorus, Ficus carica* v. *rupeatris, Cupressus semipervirens* and *Ephedra alata* (Photo 5). In addition to these the following species were recorded by the authors :

* *Pyrethrum santolinoides*	*Gomphocarpus sinaicus*
* *Phlomis aurea*	*Origanum maru*
Oenothera sp.	*Teucrium polium*
Artemisia herba-alba	*Alkanna orientalis*
Oryzopsis miliacea	*Echinops glaberrimus*
* *Nepeta septemerenata*	*Lactuca orientalis*
Diplotaxis harra	* *Scandix pinnatifera*
Melica sp.	*Callipeltis aperta*
Isatis microcarpa	* *Phagnalon sinaicum*
* *Centaurea sinaica*	*Astragalus* sp.
* *Crataegus sinaicum*	*Plantago ciliata*
Ephedra alata	*Atraphaxis spinosa* v. *sinaica*
Silene sp.	*Pityranthus triradiatus*
Bromus tectorum	

The true xerophytes are rare among these plants, especially at high altitudes. A good deal of them are confined in their distribution to Sinai mountains.

4. *Rocky Sides of Wadi Feiran :*

A number of species of trees and shrubs e. g., *Acacia* sp., *Tamarix mannifera, Moringa aptera* (Photo 6), *Ficus pseudosycamorus, Capparis Cartilaginia* and *Ephedra alata* grow abundantly on the slopes of the hills on the two sides of Wadi Feiran. These species are not represented in the cooler, less arid, granite mountains of Southern Sinai, with the exception of *Ephedra* and *Ficus.* These plants grow at all levels, and more abundantly at lower ones. They reach a considerable size, but their distribution is not uniform, being more abundant in some parts of the wadi than in others. *Acacia, Moringa* and *Tamarix* are specially common at or near Feiran oases. These are droughty plants confined in their distribution to the more northern part of South Sinai. *Moringa* and the two *Capparis* species can grow at levels higher than those reached by *Acacia* and *Tamarix*. *Acacia* continues on the slope in Wadi Feiran for some distance downstream the Monastry.

As already mentioned, *Ephedra alata* and *Zygophyllum dumosum* grow on the low rocky limestone sides of the wadi leading to Hammam Faraon.

D. — OASES AND SPRINGS

In Southern Sinai, there is a number of oases scattered in the main valleys. These receive an abundant supply of fresh water from natural springs. In wadis of the granite mountains the water has a very low salinity because it bursts out of stable rock that hardly yields any soluble material to the water passing through it. Moreover, evaporation is low in these deep wadis and water is found in grooves and hidden channels or in little shaded pools under the rock. But there are no open bodies of water that are directly exposed to evaporation and concentration. In more northern parts, where the country is open and thick deposits of fine soil cover the rocky substratum water dissolves a lot of salts as it passes through the soil, and is therefore more saline. Consequently, around the northern springs grow plants which are more salt tolerant and salt loving than those growing in the south.

Within the area studied by the present authors oases are mainly found in Wadis Feiran, El Arbaeen and El Raha, around St. Catherine Monastry and around Ayoun Musa.

1. *Feiran Oasis :*

This oasis occupies a fertile depression extending about 10 kilometers in Wadi Feiran, nearly midway between St. Catherine and Abu Zeneima. The valley in that part of its course becomes deep and narrow. The Serbal mountains on either side of the oasis are very high and have sharp peaks of 2070 m. The catchment area is very extensive and fine products of weathering are washed away by rain and deposited in the valley bed. The oasis is fed by a running spring of copious fresh water, on which grow palm groves very densely, as well as a wide variety of

fruit trees along the banks of running streams and in fruit gardens. Among the fruits grown may be mentioned olives, almonds, figs, apples, pomegranates and grapes. Crop plants, e. g., wheat and barley, are grown on the alluvial soil. Of the natural vegetation may be distinguished *Tamarix* and *Acacia*. In some of the streams grows the reed *Typha australis*, while on the higher alluvial ground grows *Verbascum sinaiticum* and *Pulicaria crispa*.

2. *Oases and Rock Pools of Wadi El Arbaeen :*

There are several small springs and rock pools distributed over the whole length of Wadi El Arbaeen. Besides, there are big cases specially abundant near the head of the wadi. The following are few examples of the springs encountered :

Not far from the mouth of the valley, in the deepest part of its section, is found a spring in the shelter of a big boulder. Fresh water flows into a narrow channel. There are cracks in the boulders surrounding the spring which are deep enough to reach the water source. In these cracks accumulates fine soil and plant litter to form a saturated medium on which *Juncus arabicus* grows (Photo 7). Soil collected from that groove and analysed yielded the results presented in Table 10.

TABLE 10

Analysis of Soil Supporting *Juncus arabicus* near a Spring in Wadi El Arbaeen

Saturation capacity (%)	=	100.1
Water retained at air dryness (%)	=	3.94
Water-soluble salts (%)	=	0.28
Concentration of soil solution (p.p.m)	=	560
Conductivity (millimhos)	=	910
Carbonate content (%)	=	0.15
Organic matter (%)	=	18.70
*p*H	=	7.0

The soil is largely made of decaying organic matter and so has a very high water retaining capacity and air-dry water content. As usual

in southern soils the salinity is moderate and the carbonate content is low. The soil reaction is neutral, unlike all other samples collected from Sinai. This is referred to the high humus content.

Another spring formed a small rock pool of very clear fresh water in the shade of boulders. The water depth is about 30 cm. Right at the water edge the soil is saturated and supports a number of cryptogamic plants including algae, mosses and ferms. *Adiantum capillus-veneris* and *Equisetum ramossissimum* *were found in a very humid place at the edge of the pool in the deep shade of boulders. Flowering plants fed by the source formed a community around the pool having the following floristic composition :

Mentha microphylla	d
Juncus arabicus	cod
Origanum maru	c

Ficus pseudosycamorus comes out through the crevices near that community. The plant cover is complete, except where rocks crop out. The soil is made of granite rock fragments mixed with organic plant remains.

A stream of running water takes off from the spring at one end of the rock pool and extends a considerable distance underneath the surface rocks.

A sample of the saturated soil surrounding the pool and supporting the above plants was analysed and the results are given in Table 11.

TABLE 11

Analysis of Soil from the Edge of a Rock Pool in Wadi El Arbaeen

			Granulometric Analysis		
			mm		%
Saturation capacity (%)	=	24.8			
Water retained at air dryness (%)	=	0.6	> 1.41	=	33.1
Water-soluble salts (%)	=	0.07	1.41-0.30	=	62.5
Concentration of soil solution (p.p.m)	=	140	0.30-0.15	=	3.0
Conductivity (millimhos)	=	250	0.15-0.07	=	0.6
Carbonate content (%)	=	0.05	< 0.07	=	0.3
Organic matter (%)	=	20.4			
*p*H	=	7.3			

In this soil, as in the previous one, the content of organic matter is very high, but apart from this its mineral constituents are coarse granite granules which do not hold much water. The fraction of the soil with particles less than 0.3 mm diameter is less than 4 %. That is why the saturation capacity and the air-dry water content are much lower in this soil than in the previous one. The carbonate content is also very small and the soil reaction is nearly neural.

In addition to small springs and rock pools there are big oases (Photo 8) and cultivated gardens fed by springs of a larger water output. In these oases *Cupressus semipervirens,* date palm and *Ficus pseudosycamorus* grow wild while olives, pomegranates, almonds, plums, grapes, apples, pears and peaches are cultivated in fruit gardens. *Verbascum* and *Solanum nigrum* are wild herbs that grow abundantly in these oases.

3. *Wadi El Raha Oasis :*

At the head of Wadi El Raha is found an oasis supporting various species of wild and cultivated fruit trees. In the midst of that oasis is found a well containing fresh water at a depth of 3 m from soil surface. During rains the water surface rises to within half a metre only. In addition to this old well, there is another, more recent, one.

Among the fruit trees growing in Wadi El Raha oasis are date palm, *Ceratonia seliqua.* pomegranates, peach, almonds and apricot.

4. *Farsh El Gebel Spring :*

Near Farsh El Gebel, midway to the summit of Gebel Musa, there is a fresh water spring round which grows a dense community of plants having the following composition :

Scirpus holoschoenus	d	*Polypogon monospeliensis*	c
Stipa sp.	cod	*Bromus rubens*	c
Galium sinaicum	c	*Juncus bufonius*	c
* *Phlomis aurea*	c	*Anagallis arvensis*	r
Veronica anagallis	c		

Algae formed a green scum along side the channel. The water course has a bare rocky bed and is found in one of the gullies. The water depth is 5-10 cm. In Table 12 is given the analysis of soil supporting the above plants.

TABLE 12

Analysis of Soil near a Spring at Farsh El Gebel

		Granulometric Analysis	
		mm	%
Saturation capacity (%)	= 33.9		
Water retained at air dryness (%)	= 1.83		
Water content (%)	= 11.24	> 1.41	= 39.8
Water-soluble salts (%)	= 0.11	1.41-0.30	= 48.7
Concentration of soil solution (p.p.m)	= 220	0.30-0.15	= 5.4
Conductivity (millimhos)	= 400	0.15-0.07	= 2.6
Carbonate content (%)	= 0.99	< 0.07	= 3.5
Organic matter (%)	= 3.23		
*p*H	= 8.0		

The soil has a relatively high water capacity on account of its high content of organic matter. The water content is at its optimum value. The soil reaction is alkaline. The salinity and carbonate content are low.

4. *Ayoun Musa Oasis :*

Ayoun Musa is a settlement in a depression of the coastal plain at about 24 km south of Suez. In that part the plain is very broad. There is a series of 12 wells arranged in one straight line parallel to the Gulf of Suez and at about 4 km from it. Some of the wells are mere shallow ponds while others are deep and lined with masonry.

Round some of the springs there are pools of clear, but brackish water, surrounded by groves of date palm and *Tamarix.* Some of the springs are only slightly brackish, while others are highly saline. The land around the springs is fine textured and saline. The relief is uneven and there are salt marshes supporting *Nitraria retusa.*

E. SALT MARSHES

In the western foreshore plain of Middle Sinai the soil is deep and the land is open and exposed. The water of wells and natural springs in that part of the Peninsula is rather brackish since it dissolves water-soluble salts found in the soil as it passes through it. Water overflows the soil surface, and as it evaporates under the influence of the high evaporating power of the air salts become precipitated, thus increasing the salinity at the surface. Accordingly the soil surrounding such springs and wells becomes saline and supports halophytic vegetation. Salt marshes are also found in depressions near the sea shore, where the saline underground water is very close to the surface or even flows over it. This type of saline habitat does not exist at all in the central mountainous country of Southern Sinai.

The following salt marshes were studied in the Gulf of Suez foreshore plain :

1. *Hammam Faraon Salt Marsh :*

At Hammam Faraon the coastal plain is very narrow, not exceeding a few hundred metres in width. The soil is sandy and the plain is bounded on the east by G. Hammam Faraon, which is a very steep limestone hill about 300 m in height. There is a salt marsh in the coastal plain covered by a small depth of water and separated from the sea by a narrow strip of land having a white crust of salt on its surface. The flooded swamp is divided into pools separated by dry patches of land. A spring of very hot water flowing underground from the mountain to the sea feeds the marsh with sulpheretted brackish water.

The salt marsh of Hammam Faraon supported marshy and halophytic vegetation. On the moist saline soil there was a green carpet of *Aeluropus* sp. In flooded areas are found *Phragmites communis* and *Juncus arabicus.* At the edge of the marsh in the relatively high ground is found an association of *Zygophyllum album, Arthrocnemon glaucum* and *Salsola inermis.* On still higher, less saline, sandy areas at a longer distance from the sea is found *Zygophyllum coccineum, Nitraria retusa* and *Tamarix articulata* on little sandy mounds.

The soil supporting *Aeluropus* has a salt crust on the surface of a sandy layer, 10 cm in depth. Underlying the white sand there is a thick layer of black soil. The land covered by *Aeluropus* is about 10 cm above the water level in the sea. A salt crust is also found on the surface of elevated patches scattered in the marsh as well as on its shores.

The spring water runs in a shallow narrow channel parallel to the sea shore. On the floor of that channel grow various species of algae and bacteria giving a mosaic of green, red and blue colouration to the substratum.

In Table 13 is given the analysis of soil from the salt marsh of Hammam Faraon under *Aeluropus.*

TABLE 13

Analysis of Soil from the Salt Marsh of Hammam Faraon

		Granulometric Analysis	
		mm	%
Saturation capacity (%)	= 23.9		
Water retained at air dryness (%)	= 0.68		
Water content (%)	= 20.15	> 1.41	= 1.8
Water-soluble salts (%)	= 0.85	1.41-0.30	= 55.1
Concentration of soil solution (p.p.m)	= 1700	0.30-0.15	= 31.4
Conductivity (millimhos)	= 2500	0.15-0.07	= 10.5
Carbonate content (%)	= 16.27	< 0.07	= 1.2
Organic matter (%)	= 0.17		
*p*H	= 7.8		

The soil of this northern locality is sandy, with a very small proportion of granules above 1.41 mm diameter. This distinguishes the northern, sandy, soils from the southern, granite, ones with a high proportion of coarse rock fragments. In the present sample most of the granules have a diameter between 1.41 and 0.15 mm.

The carbonate content of the soil is very high as compared with that of southern soils. This is referred to the fact that the surface rocks in this region are mainly limestones.

The salinity is high but the electrical conductivity is exceedingly high, indicating that most of the soluble salts found in the soil are electrolytes.

The soil is slightly alkaline and the content of organic matter is small. The actual water content is high and approaches full saturation.

2. *Salt Marsh of Wadi Gharandal :*

At the bottom of Wadi Gharandal there is a well and a spring of fresh water round which a small oasis of *Tamarix* and palm trees grows. The trees and the well are at a higher level than the salt marsh community. A little canal 30 cm in width, with brackish water, 10 cm deep extends a long distance and overflows the ground surface. Algae, especially *Chara vulgaris,* are found in the water. Near the stream are found swamp plants dominated by *Cyperus laevigatus* which forms a green carpet on the surface of the ground. It is associated with *Aeluropus, Juncus arabicus* and *Typha australis.* At the sides are found *Nitraria retusa, Alhagi maurorum* and *Cressa cretica.*

It is noticed that in the area round the stream which is covered with *Cyperus laevigatus,* there is a salt crust on the soil surface. This is followed by a yellowish layer, followed again by a black layer of varying depth (up to 20 cm). Underneath the black layer is found a layer of coarse sand resembling that under *Tamarix* in the higher part.

In Table 14 is given the analysis of two soil samples : the first from the lower level, under *Cyperus laevigatus* (A) and the second at the higher level under *Tamarix* (B).

It is seen that in both samples the salinity is high, and is much higher in the lower than in the upper level. As in all northern soils the carbonate content is very high. The soil reaction is alkaline, being more so in the lower than in the higher soil. Under *Tamarix* dense deposits of organic litter are accumulated, and consequently the organic matter content is 17.51 % as contrasted with 2.38 in the swamp. The water capacity of the swamp soil is high.

3. *Abu Zeneima Salt Marsh :*

South of Abu Zeneima rest house there is an extensive marshy plain with even relief at a slightly higher level than that of the water surface in the Gulf of Suez. The soil is sandy and wet with sea water. This saline

TABLE 14

Analysis of Soil Samples from the Salt Marsh of Wadi Gharandal

	A	B
Saturation capacity (%)	30.9	—
Water retained at air dryness (%)	1.30	—
Water-soluble salts (%)	2.70	0.90
Concentration of soil solution (p.p.m)	5400	1800
Conductivity (millimhos)	7500	2100
Carbonate content (%)	20.2	13.73
Organic matter (%)	2.38	17.51
pH	8.3	7.9

Granulometric Analysis

mm		%	%
> 1.41	=	18.4	2.6
1.41-0.30	=	45.8	41.8
0.30-0.15	=	27.8	39.8
0.15-0.07	=	6.4	12.4
< 0.17	=	1.6	3.4

area supports communities of halophytic plants. In some places there are pure associations of *Halopeplis perfoliata* (Fig. 10), in others there are pure associations of *Zygophyllum album.* In between these two there are mixed communities having the following floristic composition :

Halopeplis perfoliata	d
Zygophyllum album	c
Arthrocnemon glaucum	r
Nitraria retusa	r

The direction of the prevailing wind is NW-SE. *Halopeplis* acts as a sand-binder and the wind-drifted sand forms little, Barkhan-like mounds (Photo 9) under this plant. Each mound is about half a metre high and one metre long, extending in the direction of the prevailing wind. It has a crest at the windward and covered by the plant, and a long tapering tail behind it. The windward end is usually steep.

The soil forms a very thin hard crust at the surface, and in very saline soils it forms a hard pan at some depth.

In Table 15 is given the analysis of a soil sample under *Zygophyllum album* at a depth of 25-30 cm. The soil was wet from a depth of 10 cm downward.

TABLE 15

Analysis of Saline Soil from Abu Zeneima Salt Marsh

			Granulometric Analysis		
			mm		%
Saturation capacity (%)	=	21.7			
Water retained at air dryness (%)	=	0.54	> 1.41	=	0.7
Water content (%)	=	9.77	1.41-0.30	=	77.8
Water-soluble salts (%)	=	1.05	0.30-0.15	=	17.0
Concentration of soil solution (p.p.m)	=	2100	0.15-0.07	=	3.2
Conductivity (millimhos)	=	3400	< 0.07	=	1.2
Carbonate content (%)	=	11.69			
Organic matter (%)	=	0.09			
*p*H	=	8.1			

The greater part of the soil falls within the category of granular size 1.41-0.30 mm. Being coarse sandy the soil has a low saturation capacity and a low water retaining capacity at air dryness. The soil is alkaline, with a high content of water and salts. As usual in northern soils the carbonate content is high and the organic matter content is low. The conductivity of soil solution is very high, indicating that the dissolved salts are mostly electrolytes.

F. — SAND DUNES

Sand dunes are found in some places along the coast of the Gulf of Suez north of the latitude of Abu Zeneima, as well as in the northern wadis and plains.

In the delta of the wadi leading to Hammam Faraon are found coastal sand dunes, some of which are solidified into calcareous rock. The dunes become progressively higher as the sea shore is approached. In some

parts they form a continuous series (Photo 10). They mainly support *Tamarix articulata* which reaches a larger size than in inland parts. At the sea shore the dunes are covered with *Nitraria retusa*. *Zygophyllum album* dominates on lower dunes, while dunes supporting *Retama raetam* and *Haloxylon salicornicum* are of common occurrence in the delta of Wadi Hammam Faraon at some distance from the sea. The windward sides of the dunes are usually steep and covered with *Tamarix* roots and buried stems, while the leeward side is gently sloping and covered with loose drifted sand.

In Wadi Gharandal sand dunes are abundant and covered with *Tamarix*. A smaller proportion of the dunes are covered with *Retama* or *Nitraria*.

Between the latitudes of Wadi Gharandal and Suez, e. g., between kilos 60 and 70, *Tamarix,* and sometimes also *Haloxylon* are found on sand dunes. The dunes covered by these two species may reach a height of 3-4 m. The vegetation is very dense in that part.

At kilo 50, within the delta of Ras Sudr, there are dunes covered with *Haloxylon*.

REFERENCES

AWAD, H. (1949). La surface pre-nubienne dans le Sinaï montagneux central (partie ouest). *Rapport de la commission pour la cartographie des surfaces d'aplanissement preparé pour le Congrès Inst. de Géog.* Lisbonne, p. 149-154, 1 carte au 1 : 200.000 *e,* 1 planche photogr. hors texte et 2 figures.

—— (1951). La Montagne du Sinaï Central, étude morphologique. Le Caire, 237 P, 37 figures, 80 photogr. 2 cartes hors texte et 1 carte en pochette.

—— (1952). Presentation d'une carte morphologique du Sinai. *Bull. Inst. Desert.* Héliopolis, T. II, No. 1, Janvier.

BALL, J. (1916). The Geography and Geology of West-Central Sinai, *Egypt, Surv. Dept.,* Cairo.

BARRON, T. (1907). The Topography and Geology of the Peninsula of Sinai. (Western portion). *Egypt, Surv. Dept.,* Cairo.

BEADNELL, H. J. L. (1927). The Wilderness of Sinai, *A record of two Years recent exploration.* London (Ed. Arnold and Co.)

BOWMAN, T. S. (1931). Report on boring for oil in Egypt. Section III, *Eastern desert and adjoining islands.* Egypt, Min. Fin. (Mines and Quaries Dept.), Cairo.

HASSIB, M. (1951). Distribution of Plant Communities in Egypt. *Bull. Fac. Sci.,* Fouad I Univ. 29, 57-261.

HUME, W. F. (1904). Occurrence of Miocene Rocks in Eastern Sinai. *Geol. Mag.* London Dec. V. Vol. 1 No. 480.

—— (1906). The Topography and Geology of the Peninsula of Sinai. (South eastern portion) *Survey Dept. Egypt.*

—— (1929). The Surface Dislocations in Egypt and Sinai. *Bull. Soc. de Geogr. d'Egypte,* T. XVII.

MOON, F. W. and SADEK, H. (1921). Topography and Geology of North Sinai. Part I, Session 1919-1920. *Egypt, Min. Fin.* Cairo (*Pet. Research Ser*), *Bull.* No. 10.

—— and SADEK H. (1922). Preliminary Geological Report on the Wadi Gharandal Area (North of Gebel Hammam Faraon, West Sinai) Egypt, *Min. Fin.* Cairo (*Petrol. Research Ser.*) *Bull.* No. 12.

—— (1925). Preliminary Geological Report on Gebel Khoshera Area (West Sinai) *Egypt Min. Fin.* Cairo (*Petrol. Research Ser*). *Bull.* No. 9.

SHATA, A. (1954). Contribution to the Geology of the West Sinai Foreshore Province with Special Reference to el Haleifiya-El Zeita Area. *Ph. D. Thesis,* Cairo University.

—— (1955). The Central Geology of the Sinai Peninsula and its Relationship to Petroleum Occurrences. *Symposium on the Applied Geology in the Middle East Countries,* Ankara.

ZOHARY, M. (1935). *Die Phytographische Gliederung der Flora der Halbinsel Sinai Beih. Bot. Ctrbl.* Ab. B 52, 549-621.

PHOTO 1. Wadis : *Tamarix mannifera* forest at Bab al Mahmal, Between Wadi el Sheikh and Wadi Feiran.

PHOTO 2. Wadis : A view of Wadi El Raba at the mouth showing a pure association of *Zilla spinosa.*

PHOTO 3. Mountains : A view of a narrow gulley in Gebel Musa before Farsh el Gebel. *Phlomis aurea* is flourishing at the entrance to the gulley.

PHOTO 4. Mountains : *Phlomis aurea* (chasmophyte and endemic to Sinai) on a rocky ridge in Gebel Musa.

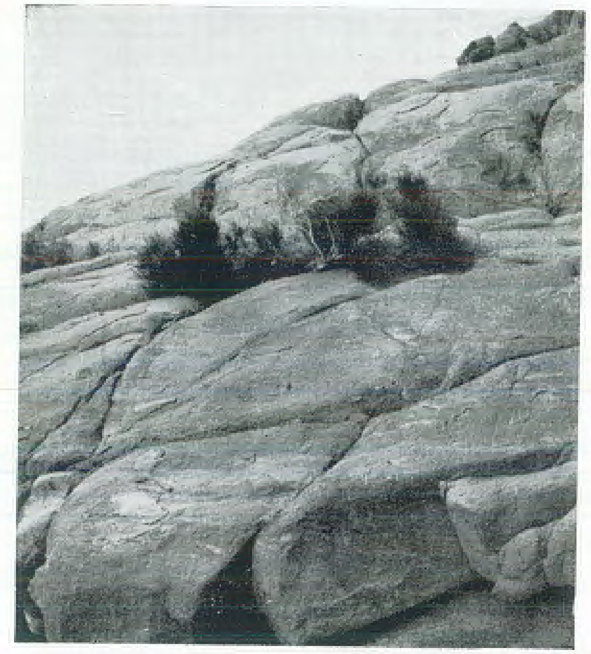


PHOTO 5. Mountains : *Ephedra alata* (chasmophyte) growing in rock crevices on Gebel Musa.

PHOTO 6. Mountains : *Moringa aptera,* a tree growing in rock crevices in Wadi Feiran near Feiran Oasis.

Photo 7. Rock pools : A spring in one of the depressions of Wadi el Arbaeen where swamp plants are found. Notice *Juncus arabicus, Mentha microphylla* and *Origanum maru*.

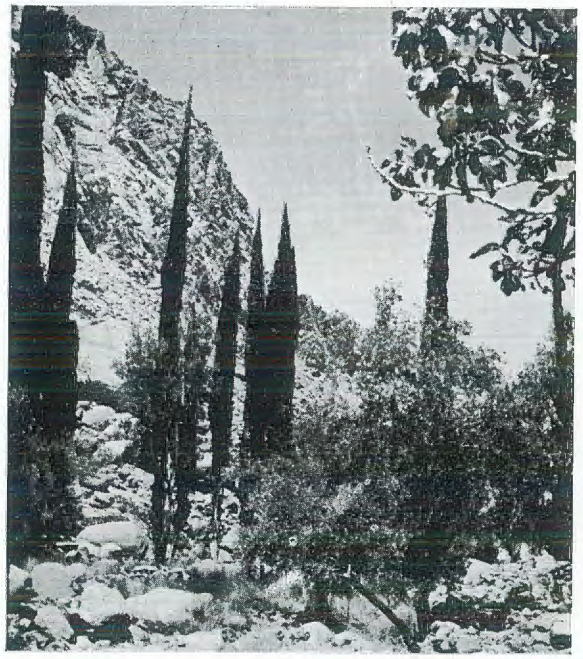


Photo 8. Oases : A view of an oasis in Wadi el Arbaeen. Of the trees growing are *Cupressus semipervirens*. *Olea europea* and *Ficus carica*.

Photo 9. Salt marshes : *Halopeplis perfoliata* in a salt marsh at Abu Zeneima, building up little dunes. The plant is found at the windward end.

Photo 10. Sand dunes : *Tamarix articulata* growing on a big sand dune.

SOME OBSERVATIONS ON THE EFFECT OF WIND ON THE DESERT VEGETATION ALONG SUEZ ROAD

BY

A. A. ABD EL RAHMAN AND M. N. EL HADIDY

INTRODUCTION

The desert plants are subject to severe winds which blow occasionally. Exposed areas are greatly affected by wind action, whereas protected areas in the shelter of hills, in valleys or in depressions are less influenced. The injurious effect of wind varies in degree, being slight in some plants which usually recover after sometime, while it is great in others leading to complete desiccation.

In the present investigation the authors aim at giving information about the changes which happened in the vegetation of a desert area along Cairo Suez Road as a result of the blowing of a severe wind early in the rainy season of 1956 (Jan., 30th). It is of particular interest to record the serious destruction of desert vegetation caused by wind action. In a previous publication the authors evaluated the efficiency of rainfall under desert conditions. But it must be taken into consideration that under natural conditions the desert vegetation is subject to severe winds which cause a great damage to vegetation, and diminish the efficiency of rainfall and productivity of the soil. In the present investigation observations were made during periods of active wind and confirmed by the study of permanent quadrats before and after the windy period.

OBSERVATIONS AND DISCUSSIONS

On Jan. 27th, 1956 wind began to blow, and attained a maximum velocity of 55 km./hr. on Jan. 30th. Observations were made during

the period of active wind. Mechanical and physiological effect on plants could be observed. Besides, wind borne sand caused burial of the aerial parts sometimes partially and sometimes completely, as in the case of prostrate plants.

Investigations dealing with the effect of wind on plants have already been carried out by a number of workers. Hopkins (1935) stated that the surface of whole fields in the Great Plains and many other regions during the spring months was blown away and the soil deposited on others. In both processes of erosion and deposition, the crop may be destroyed. Martin and Clements (1935) found that the increase in wind velocity was accompanied by increase in the transpiration rate and decrease in leaf area, as well as in height and diameter of stem. Braun-Blanquet (1932) stated « When the water supply of the plant is inadequate, strong winds produce the same wilting effects as severe drought ».

Desert plants inhabiting the desert along Suez Road vary widely in their tolerance to the action of severe winds. In this respect they can be divided into the following categories :

Perennials.

1. Mature perennial plants resist severe winds. Plants which were slightly injured recovered after a short period e.g. *Haloxylon salicornicum, Panicum turgidum, Lasiurus hirsutus, Pithyranthus tortuosus, Zilla spinosa,* and *Euphorbia kahirensis*. In the case of *Hyoscyamus muticus* the abrasive action of sand particles can be observed clearly on the surface of the fleshy leaves.

The mature perennial plants are provided with certain peculiarities which enable them to avoid serious losses of water under conditions of high evaporation, like wind and other factors. By means of these peculiarities they are enabled to protect themselves from desiccation. Protection is mainly afforded by stomatal closure associated with a highly efficient cuticle. The thick cuticle has also a considerable advantage in preventing the forceable exchange of gases caused by bending of blades under wind action, as stated by Daubenmire (1948). Also the presence of a well-developed mechanical tissue helps these plants to resist mechanical injury by wind.

Migahid and Abd El Rahman (1953) found that the perennial desert plant *Colocynthis vulgaris* avoided serious loss of water on a windy day by pulling down its transpiration rate before midday and keeping it at a minimal value from sunset till daybreak.

2. Young perennials with soft tissue, e.g. young *Zilla spinosa,* were severely injured and the majority died. The leaves dried up and turned brown.

Ephemerals.

In this category the majority of species approach mesophytes in their behaviour. They are more sensitive and more influenced by wind action. Injury in case of ephemerals may be manifested by one of the following effects.

1. *Uprooting :* This happens in extremely shallow-rooted ephemerals, with weak slender roots and relatively heavy shoots. This character which is well represented in the case of *Mesembryanthemum forskalei* facilitates the uprooting of plants by wind action. A great number of young plants of *Mesembryanthemum* were found uprooted and lying flat on the ground after the wind has ceased to blow : The roots of this plant did not exceed 10 cm in depth when the wind blew.

2. *Complete desiccation of the aerial parts :* This effect is particularly observed in plants with soft tissues which resemble mesophytes in many of their characters, as in the case of *Trigonella stellata, Malva parviflora Rumex vesicarius, Emex spinosus* and *Diplotaxis acris*. These mesomorphic desert ephemerals were so damaged by wind that they withered completely Also *Mesembryanthemum* plants, with fleshy tissues, suffered from desiccation.

3. *Transient wilting, followed by recovery :* As in *Matthiola livida*. In case of *Mesembryanthemum forskalei* the apices of the fleshy cylindrical leaves shrivelled and dried up, but the plants survived.

4. *Burial under drifted sand :* In the case of plants with soft fleshy aerial parts, e.g., *Mesembryanthemum forskalei,* the accumulation of wind-borne sand destroyed the plant tissues. Other plants, such as *Erodium pulverulentum, Schismus barbatus, Platago ovata* and *Filago spathiolata,*

can tolerate burial by the sand. Damage to such plants may be brought about by other causes.

The observations made here on the changes caused by wind action were confirmed by comparison of chart quadrats (Figs. 1-4), of 100 m² area before and after wind. This comparison was made in two areas near the desert laboratory at kilo 35 Cairo-Suez Road, one exposed and the other protected behind a hill.

Examination of the permanent qaudrats (Figs. 1 and 2) before and after wind in the exposed area shows that the number of individuals per 100 m² fell from 1156 to 669, i.e., to 58 % of their original number. The main loss occured in the young, developing plants, of *Mesembryanthemum forskalei,* which decreased from 828 to 424 (Table 1). This great reduction in the number of *Mesembryanthemum* individuals to about 51 % was due to uprooting, and to desiccation of the tops. The individuals which exhibited partial desiccation at the apices of the succulent leaves recovered after sometime. Other plants, much less common, such as *Trigonella stellata* and *Diplotaxis acris,* were severely injured through complete desiccation of their tops, and the number of individuals was greatly reduced. In the case of *Trigonella* the number of individuals decreased from 36 to 11, whereas in the case of *Diplotaxis* all the individuals vanished completely (Table 1). *Plantago ovata* plants showed a reduction from 82 to 38, *Schismus barbatus* from 62 to 45 and *Centaurea pallescense* from 33 to 25. Plants like *Erodium pulverulentum* with rosette leaves adhering to the soil surface were but slightly injured and the number of individuals decreased from 5 to 4.

Key to symbols used in the quadrats

•	*Mesembryanthemum forskalei*	Ⓜ	*Matthiola livida*
T	*Trigonella stellata*	▭	*Haloxylon salicornicum*
Υ	*Diplotaxis acris*	Z	*Zilla spinosa*
Γ	*Plantago ovata*	▥	*Panicum turgidum*
X	*Schismus barbatus*	▦	*Lasiurus hirsutus*
o	*Centaurea pallescense*	R	*Euphorbia kahirensis*
I	*Ifloga spicata*	★	*Pithyranthus tortuosus*
E	*Erodium pulverulentum*	⊙	*Farsetia aegyptiaca*
Sn	*Senecio desfontainei*		

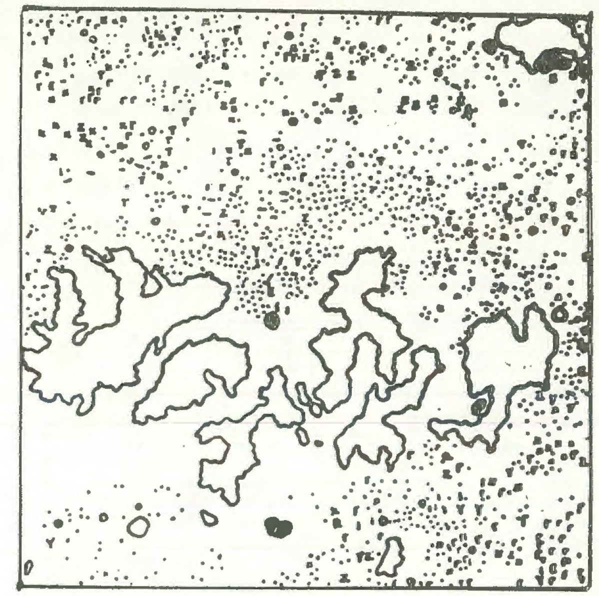


FIG. 1. Chart quadrat A (100 m²) showing the plant cover, density and distribution of plants in an exposed area on January 25th, 1956 before the windy period. Total percentage cover 22.7 % and percentage cover of ephemerals 9.0 %.

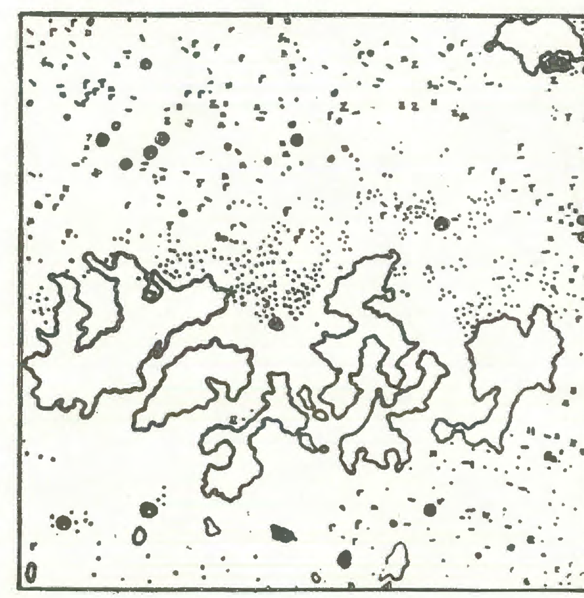


FIG. 2. Chart quadrat A′ (100 m²) showing the plant cover, density and distribution of plants in an exposed area on February 25th, 1956 after wind. Total percentage cover 19.4 %, and percentage cover of ephemerals 6.2 %.

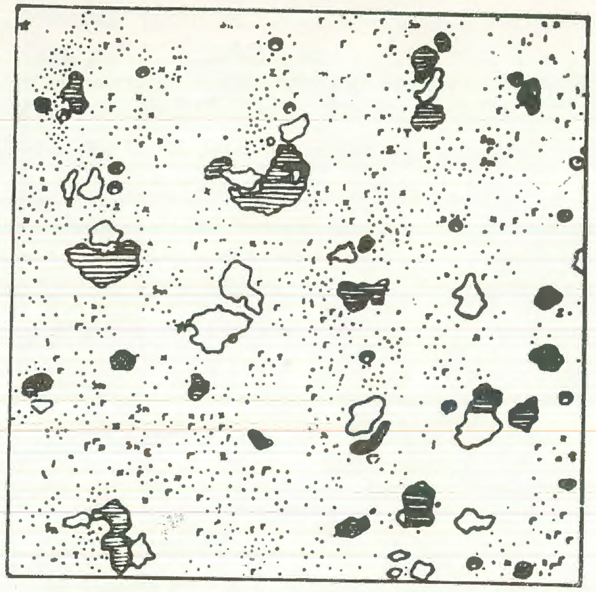


FIG. 3. Chart quadrat B (100 m²) showing the plant cover, density and distribution of plants in a protected area in the shelter of a hill on January 25th, 1956 before wind. Total percentage cover 16.0 % and percentage cover of ephemerals 8.1 %.

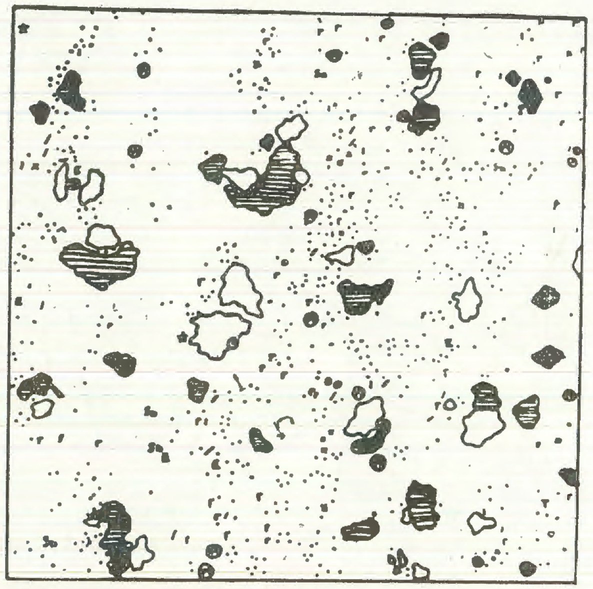


FIG. 4. Chart quadrat B′ (100 m²) showing the plant cover, density and distribution of plants in a protected area in the shelter of a hill on February 25th, 1956 after wind. Total percentage cover 15.2 % and percentage cover of ephemerals 7.0 %.

TABLE 1

The Change in Number of Individuals Occupying an Area of 100 m² Exposed to Wind.

Species	Number of individuals/100 m²	
	Before wind	after wind
Ephemerals		
Mesembryanthemum forskalei	828	424
Trigonella stellata	36	11
Diplotaxis acris	12	0
Plantago ovata	82	38
Schismus barbatus	62	45
Centaurea pallescense	33	25
Ifloga spicata	52	77
Erodium pulverulentum	5	4
Senecio desfontainei	2	5
Matthiola livida	—	12
Perennials		
Haloxylon salicornicum	15	14
Zilla spinosa	22	8
Panicum turgidum	3	3
Lasiurus hirsutus	3	3
Euphorbia kahirensis	1	0
Total number of individuals	1156	669

Few species, such as *Ifloga spicata* and *Senecio desfontainei*, showed some increase in number of individuals. This increase may be referred to the fact that the developing plants can resist action of wind and that new seedlings of these plants appeared after the wind.

TABLE 2

The Change in the Number of Individuals Occupying an Area of 100 m^2 Protected Behind a Hill.

Species	Number of individuals/100 m^2 Before wind	after wind
Ephemerals		
Mesembryanthemum forskalei	776	546
Trigonella stellata	2	1
Plantago ovata	65	47
Schismus barbatus	33	15
Ifloga spicata	31	34
Erodium pulverulentum	3	4
Matthiola livida	9	15
Perennials		
Haloxylon salicornicum	23	20
Zilla spinosa	3	1
Panicum turgidum	25	25
Lasiurus hirsutus	3	3
Farsetia aegyptiaca	3	3
Pithyranthus tortuosus	2	2
Total number of individuals	978	716

The mature perennials did not show any remarkable change in the number of individuals. In the case of *Haloxylon salicornicum* the number of individuals exhibited a slight reduction from 15 to 14, whereas with *Panicum turgidum* and *Lasiurus hirsutus* it remained constant. Young plants of *Zilla spinosa* with delicate soft tissue were greatly damaged and a great proportion completely dried up. The number of individuals decreased from 22 to 8.

Examination of the permanent quadrats (Figs. 3 and 4) in the relatively protected area shows that the loss in the number of individuals after wind was considerably less than in the exposed area. The total number of individuals occupying the area of 100 m^2 decreased from 978 to 716 (Table 2). The percentage of individuals destroyed by the action of wind in the relatively protected area (27 %) was much less than that in the exposed area (42 %). The number of *Mesembryanthemum* individuals decreased from 776 to 546. This is equivalent to 30 %, as compared with 49 % in the exposed area.

The wind had a marked influence on the area covered by vegetation through the destruction and mortality of some individuals. Examination of the area covered by plants in the quadrats plotted in the exposed area before and after wind shows that the total cover decreased from 22.7 % to 19.4 %. This considerable reduction in the cover of 15 % of its value before wind was referred to the decrease in the area covered by ephemerals, since the change in the area covered by perennials was negligible. The area covered by ephemerals exhibited a reduction of 31 % due to wind action.

In the protected area the decrease in the area covered by plants was much less than in the exposed area. The total cover showed a slight reduction of 5 % in the protected area in comparison with 15 % in the exposed area. In the former the decrease in the area covered by ephemerals was 13 %, whereas in the exposed area it amounted to 31 %.

SUMMARY

The desert vegetation along Suez Road is subject to severe winds. On January 27th, the wind began to blow and attained a velocity of 55 km./hr. on the 30th, of the same month. Observations were taken during the blowing of wind, and permanent quadrats were plotted before and after the wind. The latter had a great distructive influence on the young developing plants appearing in the rainy season. The damage to these plants was due to uprooting or desiccation. The wind-borne sand destroyed the aerial parts of some plants with soft tissue. The loss in number of individuals due to wind action amounted to 49 % in exposed areas. In relatively protected areas the loss was less, reaching about 27 %. The mature perennial plants are provided with structural and physio-

logical peculiarities which enable them to tolerate the action of wind, whereas the young perennials are severely damaged.

In the exposed area the total cover showed a reduction of 15 % whereas in the protected area it was about 5 %. The reduction in the total cover was referred to the decrease in the area covered by ephemerals, since the change in the area covered by perennials was negligible. The decrease in the percentage cover of ephemerals in the exposed area was 31 % and in the protected area 13 %.

REFERENCES

Braun-Blanquet, J. (1932). Plant sociology. Translated by G. D. Fuller and H. S. Conard. McGraw—*Hill Book Company, Inc.*, New York.

Daubenmire, R. F. (1948). Plants and environment. *A text book of plant autecology.* John Wiley and Sons, Inc., New York.

Hopkins, E. S., *et al.* (1935). Soil drifting control in the prairie province. *Dominion of Canada, Dept. Agric. Bull.* 179 (n.s.).

Martin, E. V. and Clements, F. E. (1935). Studies of the effect of artificial wind on growth and transpiration in *Helianthus annuas. Plant Physiol.,* 10 : 613-636.

Migahid, A. M. and Abd El Rahman, A. A. (1953). Studies in the water economy of Egyptian deserts. III. Observations on the drought resistance of desert plants. *Bull. Inst. du Désert d'Égypte,* 3, 59-83.

GROUND WATER AND GEOMORPHOGENY OF THE NORTHERN SECTOR OF WADI EL ARISH BASIN

BY

A. SHATA

ABSTRACT

In the North Sinai Foreshore area, where this basin exists, there is a strong harmony between the regional geologic structure and the occurring morphologic features. This part of Sinai represents the northern flanks of El Maghara-El Halal major upwarp. In this upwarp region, Wadi El Arish is developed into an antecedent feature and is connected to many lateral subsequent tributaries which from their radial pattern reveal carefully the existing fold morphology. On the other hand, in the downwarp region, Wadi El Arish is rather simple and lacks any real tributaries. On both sides of the present channel of the wadi, three main terraces are known and were followed at a uniform height of more or less 10 ms., 22 ms., and 35 ms. respectively above it. These terraces, indicating the young morphology of the surface, were formed during the lowering down of the wadi in Holocene times. This phenomenon was of course connected with the lowering down of the level of the Mediterranean relative to the land which has its start at least in Sicilian times. This information has been found to be of supreme importance when evaluating the water potentialities of this portion of Sinai.

INTRODUCTION

1. General Outline.

The Wadi El Arish basin, having a well developed hydrographic pattern of the dendritic type, is considered as one of the most important

geographical features of the Sinai Peninsula. It covers an area of about 20.000 sq. km. which is equivalent to 1/3 of the Sinai total area. This basin is almost responsible for the Mediterranean drainage system of Central and Northern Sinai. West Sinai and East Sinai, on the other hand, have their own drainage lines which are directed towards the Gulf of Suez and the Gulf of Aqaba respectively.

From its intake area, situated in the highlands of Central Sinai, to its outlet into the Mediterranean, in the vicinity of El Arish town, Wadi El Arish has a length of 250 kms.

Wadi El Arish has two main tributaries, a western one by the name of Wadi El Bruk, which has its intake from the calcareous plateau region of West Sinai particularly around Gebel Somar, Gebel Badhie and Gebel El Raha; and an eastern one by the name of Wadi Aqaba which extends eastward into the highlands of the Negeb-Aqaba Region. In addition to these, subsidiary tributaries join Wadi El Arish further downstream, of which we mention Wadi El Jaifi, Wadi El Muwelih, Wadi El Azarik, Wadi Hareidin and eventually Wadi El Maazar. With the exception of Wadi El Maazar, these tributaries extend into the Eocene Plateau occupying Eastern Sinai and part of Western Palestine. To the west, we have Wadi El Hadhira draining the fold ridge of Gebel El Halal and joining the master stream of Wadi El Arish before El Dhaiqa Gorge and also Wadi El Hassana which is responsible for the drainage pattern of El Maghara-Yelleg anticlinal ridges. This last wadi runs in a north-east direction to join Wadi El Arish, approximately in the Lihfin area. From El Daiqa Gorge northward to the Mediterranean, no real tributaries are noted to join the main wadi. In this respect Wadi El Arish could be compared to many classical drainage lines known in the arid and semi-arid regions. Outside the Sinai area to the east, Wadi Ghaza in Palestine has many similar characteristics.

On regional basis, Wadi El Arish runs in a northward direction where it follows the rather gentle slopes of the main Sinai upwarp. The longitudinal gradients of the wadi varies considerably from the south northwards. The general gradients are of the order of 4 m./km. (1000 ms. to sea level, over a distance of 250 km.) (Fig. 1). Along the whole length of the wadi it is subdivided into three portions :—

a) The southern portion; having gradients of the order of 6 m./km. (1000 m. to 400 m. over a distance of 100 km.).

b) The central and northern portions; having gradients of the order of 2.5 m. /km. (400 to 150 m. over a distance of 100 km.).

c) The foreshore portion; having gradients of the order of 2 m./km. (140 m. to sea level over a distance of 70 km.).

In the southern portion, the wadi traverses the elevated plateau of El Tih and the southern downwarp area of El Maghara-Yelleg-El Halal upwarp. In the central and northern portions the wadi traverses the upwarp region of El Maghara-Yelleg-El Halal where it changes in some places (El Mitmetni and El Halal) from a simple consequent stream to a rather complicated antecedent one (Awad, Hassân, 1951). Finally, in the far northern portion, the wadi traverses the northern downwarp area of El Halal-Yelleg-El Maghara and continues into the Sinai Coastal plain.

It is not surprising, therefore, to note that the regional and local geologic structure, with folding than faulting, are the main factors affecting the landscape of Wadi El Arish Basin. The rock exposures with dominant flinty chalk and limestones of Eocene age,

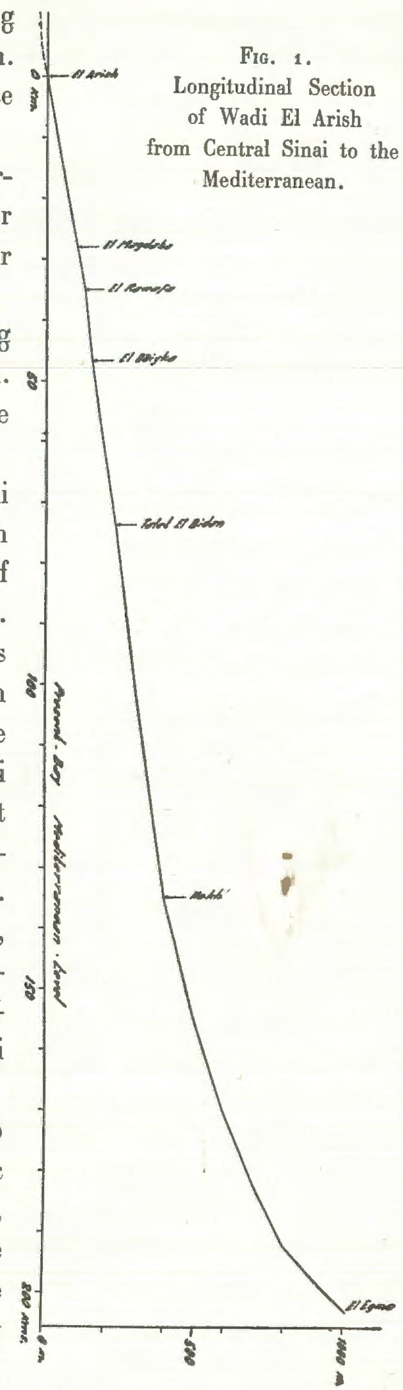


Fig. 1. Longitudinal Section of Wadi El Arish from Central Sinai to the Mediterranean.

saliferous marls and limestones of Palaeocene and Cretaceous ages are also effective. In El Daiqa area local transverse faults seem to have played a certain part in initiating the occurring gorge.

This paper is devoted to the study of the morphological features displayed in the northern portion of Wadi El Arish Basin which traverses the foreshore plain of North Sinai. In this part of the Sinai peninsula no other drainage lines have continued from the Sinai main land mass into the Mediterranean. Eastward in Palestine, Wadi Ghaza runs parallel to Wadi El Arish i.e. in a NW-SE direction and is also a remarkable feature in the foreshore area.

2. Location of the Area.

The northern portion of Wadi El Arish Basin has a length, from south to north, of 70 km. and an average width, from east to west, of 5 km. It occupies, therefore, an area of about 350 sq. km. which equals 84.000 feddans. To the south, this area is bounded by El Halal anticlinal ridge (Lat. 30°45'N) and to the north it is bounded by the Mediterranean Coast (Lat. 31°10'N).

Within this area the field work, was essentially confined to the consequent depression Wadi El Arish and its elevated banks actually developed into a series of erosion terraces rising 10, 22 and 35 m. respectively above the present channel. Some of these terraces form remarkable features and were followed for long distances, which exceed 50 km., in spite of the loose alluvial formations in which they were carved. Our work was sometimes extended to include portions of El Halal and Risan Aneiza upland areas and their foot-hill slopes. These slopes merge gradually into the extensive foreshore plain, actually developed into a piedment surface running to near reaches of the present Mediterranean coast. On top of this plain immense sand accumulations, locally developed into low dunes, are found.

MORPHOLOGIC SUBDIVISIONS

On morphologic basis, the northern sector of Wadi El Arish Basin is distinguished into three main divisions (Plate I and Fig. 2 and 3).

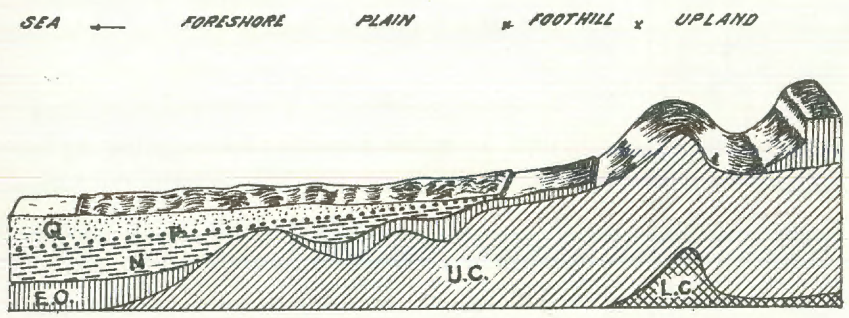


Fig. 2. Blockdiagram Section through the Area L. C. Lower Cretaceous; U. C. Upper Cretaceous; E. O. Eocene + Oligocene; N. Neogene; P. Pliocene; Q. Quaternary.

1. El Halal Upland Area.
2. The Foot-hill Slopes.
3. The Foreshore Plain, which is distinct into the following :—

a) The High Plain.
b) The Uppermost Terraces of Wadi El Arish.
c) The Middle Terraces of Wadi El Arish.
d) The Lower Terraces of Wadi El Arish.
e) The Present Channel of Wadi El Arish, and its flood plain.

We shall now proceed to deal with the main characteristics of the different features :—

El Halal Upland Area :

This upland area occupies the southern portion of the region which we investigated and constitutes the northeast terminus of El Halal main ridge. This is a conspicuous anticlinal fold running in a NE-SW direction. Similar to the North Sinai fold ridges, which all have a double plunge system, El Halal upland area slopes both to the southeast and northwest. In the southeast direction the slope is considerably steeper, which is obviously related to the regional structural attitude.

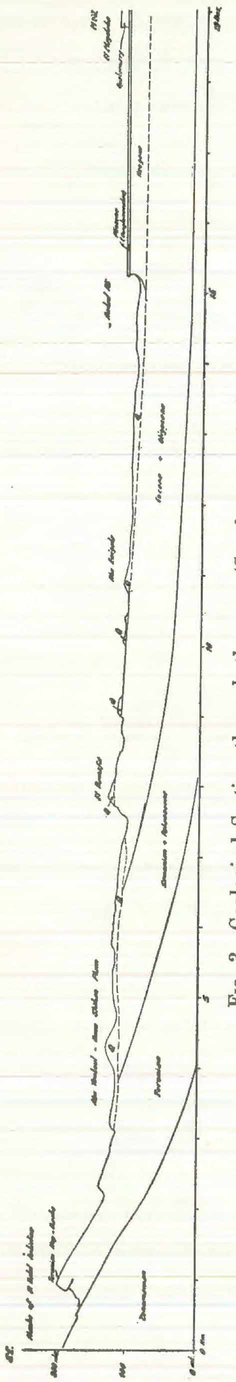


Fig. 3. Geological Section through the area (Southern portion).

El Halal upland area rises more than 200 m. above the surrounding plain and is mainly underlain by the Cenomanian weather resistant limestones and dolomites. It is dissected by a number of radial transverse faults, which though less noted morphologically have some influence on the occurring hydrographic pattern. The marginal portions of this upland area are occupied by softer formations dominated by marls and chalky limestones belonging to the Senonian and Turonian. Eventually the outer plain is essentially occupied by the Senonian soft chalks and Palaeocene marls. Within this part of Wadi El Arish Basin, many classical examples of the fold morphology are represented which are typified by the remarkable radial drainage pattern showing characteristic short « ruzes », « cluses», « gaps » ... etc. which all result in giving the surface a strongly worn out appearance. Neverthless, it can be stated that the occuring morphological features are not quite old, as erosion has not gone to the stage to carve the upfold structure into a peneplain.

The growth of El Halal Upland Area was associated with the earth movements which lead to the formation of the regional belt of domal structures. These are well displayed in North Sinai. The formation of this belt has its start in pre-Cretaceous times but it became developed during the Turonian (Middle Cretaceous). Further growth of this upland area took place in late Tertiary times, particularily during the Miocene. During the late Pliocene and early Pleistocene times it certainly reached a climax in the morphological development when the strong phase

of earth movements set in, with the result that the features were more raised, the radial fault system developed and the drainage pattern took on much of its present shape. Weathering processes acting on this upland area, resulted in the removal of the Eocene and Senonian cover from the crestal area (these are still known on the flanks) and the surface became later on worn out of any soil and vegetation cover (Plate II and Fig. 4). This last phase was connected with the aridity which started in early Holocene times and is still continued.

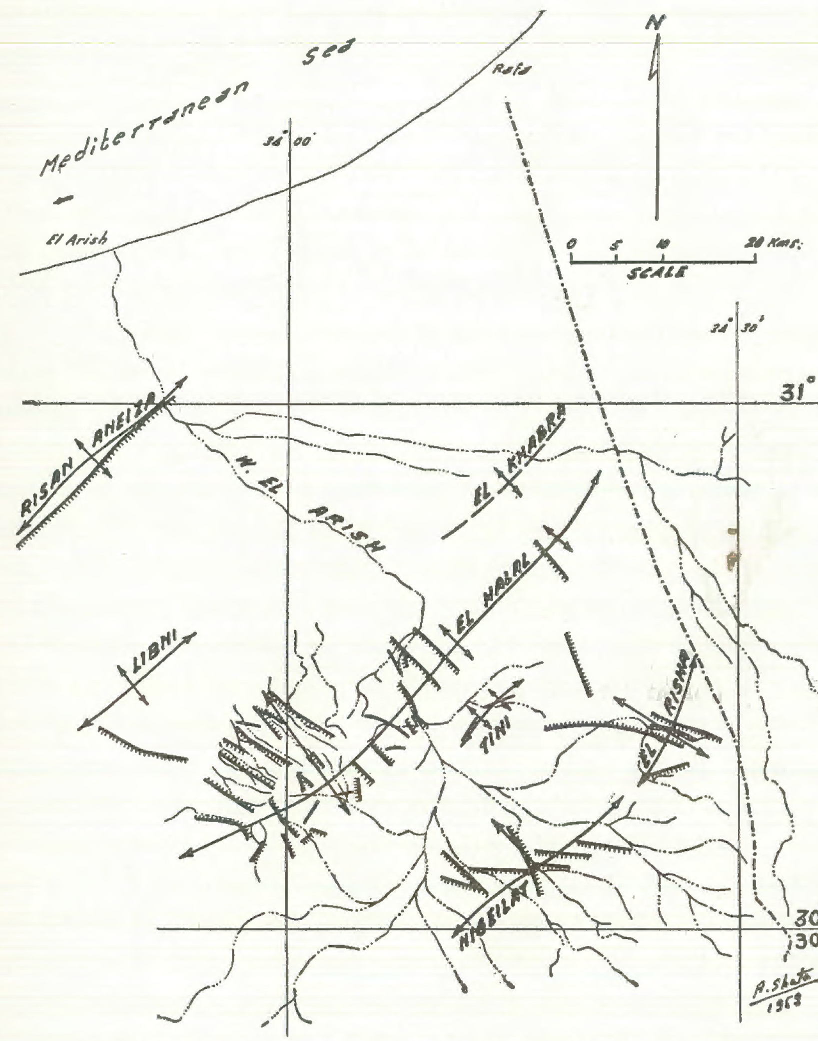


Fig. 4. Main anticlinal axes and fracture lines of Northeast Sinai.

El Halal Upland Area is crossed in a NW-SE direction by the master stream of Wadi El Arish, with the formation of a characteristic gorge (El Daiqa) which is bounded by relatively high walls of Cenomanian limestones. These rise to more than 150 m. above the present channel. In the early stages of the development of this gorge the wadi has maintained its line of flow across the NE-SW anticlinal ridge which was in a process of formation. Erosion appeared to have kept pace with the slowly uplifted strata. These attained most of their present shape in Plio-Pleistocene times. Radial faulting, which took place contemporaneously with the folding phenomenon, has definitely accelerated the formation of El Daiqa gorge.

About the present gradients of Wadi El Arish in El Daiqa area, they are of the order of 2.5 m./km., but there are indications that in some older periods they were much less steeper. Drilling, which was made in 1947 at the upstream entrance of El Daiqa gorge, has revealed the presence of at least 40 m. of wadi alluvium before hitting the bed rock. This may mean that, at one stage of the evolution of Wadi El Arish, it has aggraded down its course to a level, approximately 40 m. below the present surface. Knowing that the surface elevation at the drilling site is about + 170 m., then we would expect the bed rock in this particular spot to have an altitude of about + 130 m. In addition, we know that at El Rawafa, 7 km. to the north-east of El Daiqa gorge, the Eocene flinty chalk beds are exposed and have an altitude of + 125 m. Then we can figure out that the gradients of the wadi during this old period were of the order of $\frac{1}{2}$ m./km. This may account for the occurrence of the temporary ponding which took place both upstream before the flood water found its way into this gorge and also downstream when this same water became choked again in El Rawafa gorge. The changes of the gradients of Wadi El Arish in El Daiqa area were presumably connected with the local oscillation along the axis of El Halal anticlinal ridge.

Before the end of the talk about El Halal upland area, we might as well refer to Risan Aneiza which occurs in the vicinity of Bir Lihfin. This lies 15 km. to the south of the Mediterranean coast. Risan Aneiza represents the north-east terminus of El Maghara anticlinal ridge which is separated from El Halal ridge by a wide and deep syncline.

These two ridges are both elements of a major upwarp zone which characterises the North Sinai area (Picard, 1943 and Shata, 1955). On geological and morphological basis, Risan Aneiza upland area bears a strong similarity to El Halal area. The following are, however, points of specific interest :—

1. Risan Aneiza upland area is fully responsible for the formation of the Lihfin gorge which is located on its northern flanks. This flank region is entirely masked underneath the alluvial deposits which dominate the surface horizons of our area. The Lihfin gorge traverses the upland area in a NW-SE direction i.e. perpendicular to the axis of the fold structure.

2. Risan Aneiza upland area, formed essentially of barren slopes of Upper Cretaceous limestone, is almost covered with drift sand accumulations. The crestal portion of this upland area is a low erosional «cirque» and is occupied by soft Jurassic and Lower Cretaceous sandstone beds.

3. Although the details of the morphologic features which are displayed at Risan Aneiza upland area are not fully understood, we have evidence to say that by analogy these are of the type characteristic to folds. Longitudinal faulting affecting the crestal portion of this upland area has made some local modifications. As far as the drainage lines are concerned, we expect this upland area to be dissected by a number of radial drainage lines. Some of these lines find definitely their way into wadi El Arish basin particularly in the area north of Lihfin gorge. These are considered by us as important contributors to the water supply of El Arish basin. Although these drainage lines are hidden underneath the young sand cover, their existence is felt on the western bank of the wadi which is not smooth, but is developed into a number of irregular loops (Fig. 5 and Plate I).

The Foot-hill Slopes.

Between El Halal upland area and the foreshore plain there is a transitional zone situated at a height between 200 m. and 125 m. This zone has a width of 10 km. and extends from the downstream

side of El Daiqa gorge to the broken bridge at Abu Ewigeila. It is occupied by soft strata belonging to the Senonian, Palaeocene and Eocene which are all dominated by chalky and marly facies. The surface of this zone is partly covered with gravels, drift sand and alluvium and

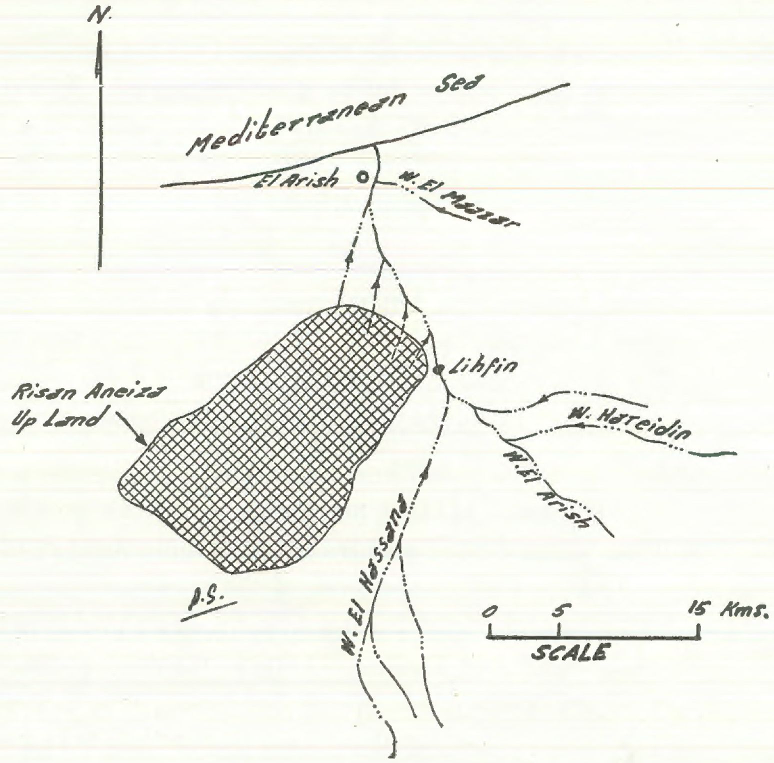


Fig. 5. Sketch Map to show possible drainage lines from Raisan Aneiza upland joining Wadi El Arish master stream.

is almost featureless except for some local undulations. On structural basis, the transitional zone represents the northern flank of El Halal upfold ridge and merges gradually into the vast downfold region located between El Halal and Risan Aneiza anticlinal axes.

The foot-hill region is traversed by the main channel of Wadi El Arish where it has many different salient features especially with regards to the directions, the gradients, the lateral tributaries and eventually the strata in which it is incised. In El Daiqa region, the wadi runs almost

in a north-south direction, but after its exit it swings rapidly to the east and then turns gradually to maintain a N-S direction. Before the entrance into El Rawafa gorge the Wadi makes another swing but in the westward direction. Between El Daiqa gorge and El Rawafa gorge the Wadi is thus forming a wide loop passing across an almost flat country (Um Shihan and Abu Yentoul plains) which is underlain by the soft Senonian and Palaeocene formations. To the east and west, this flat country is bounded by low lying hills covered with gravels and drift sand (Um Kataf and El Efeira, + 200 m.). These low lying hills are almost continuous and include between them El Rawafa hills (170 m.), and are all underlain by harder beds composed essentially of flinty chalk belonging to the Eocene period.

In the foot-hill region the general gradients of the Wadi are of the order of 2.5 m./km., but in the limited portion extending from El Rawafa to the Abu Ewigeila broken bridge (a distance of 3 km.), these are increased to 5 m./km. In this particular portion the Eocene chalk and limestone beds are exposed in the wadi bed and show a downstream dip of 3° to 5°. At its exit from El Daiqa gorge, Wadi El Arish mainstream—actually a transversal consequent—joins two main longitudinal subsequents namely Abu Yentoul and Um Shihan which have their intake from El Halal upland mass and reveal carefully the fold morphology of that particular area. From this area northward to the Abu Ewigeila broken bridge, the main Wadi does not receive any real tributary and thus the actual fold slopes occurring in the subsoil are not by any means indicated. From this point of view it appears that the morphology of this particular portion of the foot-hill slope is quite young, and is therefore comparable to the foreshore plain. In these two regions the old drainage lines are hidden underneath the Quaternary sediments (gravels, alluvium and drift sand).

This may lead us to a short talk about the evolution of Wadi El Arish in that particular portion of Sinai. An important fact to mention is that when Wadi El Arish is released from El Rawafa gorge in the vicinity of Abu Ewigeila, it entered into an open plain where we have immense accumulations of modern alluvial deposits overlying a variety of Neogene sediments. These are only witnessed in the vicinity of Awlad Ali. Of

special interest among these sediments is a conspicuous deltaic formation (alternating gravels, gypseous clay and sandstone) and a beach conglomerate bearing Pliocene rare fossils. The present channel of Wadi El Arish is incised in these sediments. Bearing on the facts above mentioned we may be justified in assuming that the evolution of Wadi El Arish would date back at least to Miocene times where there was an ancient and rather narrow foreshore plain and the old Wadi entered the Pliocene Sea in the area of Awlad Ali (Fig. 6).

In Upper Pliocene or Plio-Pleistocene times when North Sinai was subjected to strong tectonic movements (with folding and uplift), El Halal, Yelleg, El Maghara etc. anticlinal ridges were developed enough to attain their present proportions. With the rise of the land, the old Wadi El Arish deepened its channel into the Upper Cretaceous (El Daiqa gorge) and made itself felt in the Foot-hill slopes (El Rawafa gorge).

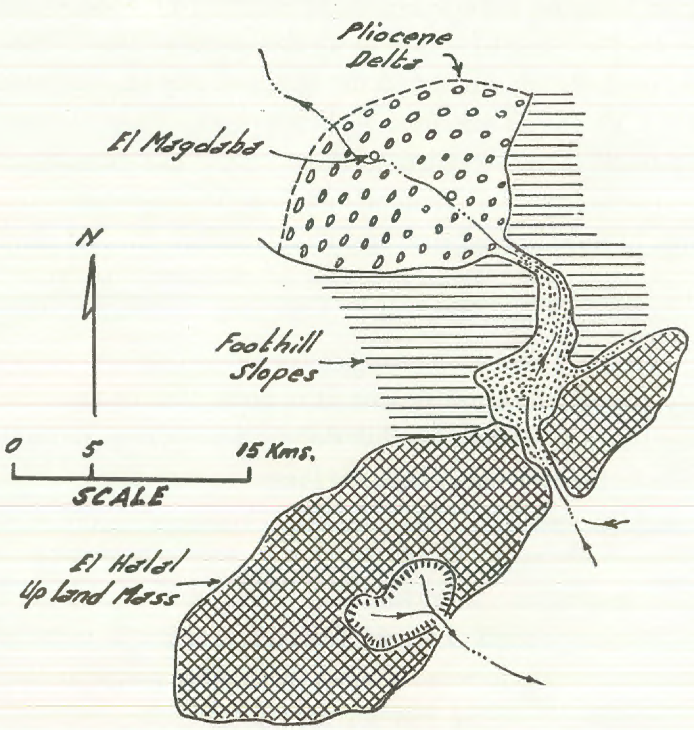


Fig. 6. Sketch Map to show position of the Pliocene delta of Wadi El Arish.

At the same time, this Wadi started to discharge its load into the Pliocene Sea in the vicinity of Awlad Ali with the development of an old delta (Fig. 6). With the advance of time (Pleistocene), further products were heaped onto the already formed Pliocene Coastal Plain and a gigantic alluvial fan, which produced the present piedmont slope, began to be formed and extended to near reaches of the present Mediterranean coast. The building material of this alluvial fan was derived from the denudation of the elevated land masses of Central and Northern Sinai. These are dominated by limestone and chalk belonging to the Upper Cretaceous and Eocene; and saliferous marls (Esna shales) of the Palaeocene. It is not surprising, therefore, to note that the fan deposits have a very rich calcareous content. The effect of the saliferous marls —containing a certain percentage of nitrate salts—is also felt in these deposits. In Holocene times, the Wadi had incised its present channel into the fan deposits with the formation of three remarkable terraces standing at a regular height above the present wadi floor.

The Foreshore Plain.

The North Sinai Foreshore Plain represents an extensive structural depression lying on the northern flank of El Halal-El Maghara upwarp. In this depression, which extends into the Ghaza lowland region, are now deposited great quantities of drift sands. These sands are locally developed into conspicuous low lying dunes mainly oriented in a W.NW-E.SE direction. This regional depression is traversed by the main Wadi El Arish and Wadi Ghaza basins.

In our area, the Foreshore Plain slopes regionally in a northward direction at the rate of 2 m./km. But on the approach to the Lihfin gorge, a certain local rise of plain is maintained. From Lihfin northward, i.e. towards the present Mediterranean coast, this plain lowers down suddenly and forms several conspicuous steps facing the north. These run in an east-west direction i.e. parallel to the present Mediterranean coast. These steps may mark the successive stages in the lowering down of the level of the Mediterranean when receding to its present position in Pleistocene and Holocene times. At least four main stages are recogniz-

able which mark the approximate position of the Mediterranean shorelines during the following stages (Plate I) :—

a) Sicilian stage (elevation +82 m. above the present sea level) occurring at a distance of 10 km. from the present coast.

b) Melazzian stage (elevation 55 to 62 m. above the present sea level) occurring at a distance of 6 km. from the present coast.

c) Tyrrhenain and Main Monastirian stages (elevation +33 m. and 22 m.? above the present sea level) occurring at a distance of 2 km. from the present coast.

d) Pre-Roman or Late Monastirian (elevation +12 m. above the present sea level) occurring at a distance less than 100 m. from the present coast.

As stated before, the Foreshore Plain is dominated by the master stream of Wadi El Arish, which from its exit at El Rawafa gorge northward to the Mediterranean i.e. over a distance of 50 km., it runs in a NW direction and forms many broad meandering loops. Minor wadis namely Dakhakhin, El Faheidiya, Hareidin, El Maazar and probably also El Hassana, join this wadi both from the east and from the west. The main wadi is banked with characteristic alluvial terraces which were all followed at a uniform height above the present channel. With regard to the wadis which join the master stream in this particular region, they are very simple, smooth and shallow, and differ very much from the branching subsequent wadis which are known in the region south of El Halal Upland Area. In the foreshore area, Wadi El Arish is, therefore, poor in real tributaries, but we must confess that the recent alluvial and dune formations has certainly masked many of the old drainage lines especially in the vicinity of Risan Aneiza Upland area. Wadi El Arish itself, seems in this same region to be a rather young feature (Pleistocene and Holocene). This is indicated by the well developed and almost constant three terraces which occur on both sides of the wadi. These terraces are almost everywhere remarkably well preserved, in spite of the soft alluvial formations which are dominant in the foreshore area, and were presumably formed at successive intervals in the downward erosion of its channel.

These terraces occur at uniform heights above the present channel, thus :—

Level	Abu Ewigeila (South)	Hareidin (Middle)	El Arish (North)
Upper terrace	+ 125 m	+ 93 m	+ 35 m
Middle terrace	+ 115 m	+ 80 m	+ 22 m
Lower terrace	+ 102 m	+ 70 m	+ 12 m
Present Channel	+ 92 m	+ 61 m	+ 2 m

There is always a difference in height of about 33 m. between the present channel and the uppermost level of Wadi El Arish.

The alluvial deposits are not the only geological formations which we have in the Foreshore Plain. Drift sand accumulations and local gravel patches are also known. In the southern portion of that plain, particularly in the area between Awlad Ali and El Magdaba, Miocene yellow marls and Pliocene gypseous clays and conglomerates are recognized but these are masked underneath the modern alluvial deposits. The Pliocene conglomerates known at Awlad Ali (+109 m.), overlie the Miocene marls and form a conspicuous elongate and flat topped hill situated in the Wadi El Arish depression. These conglomerates dip slowly in the northward direction and appear again in the Wadi Bed at El Magdaba (+80 m.) with a fall of 21 m. in a horizontal distance of 5 km. If we assume a regular northward slope at that rate (approximately 4 m/km.), the similar formation would be anticipated at El Arish town, along the coast, at a depth of 130 m., of course, when there are no structural complications. These conglomerates form the foundation on which were laid the alluvial and diluvial deposits and then the aeolian drift sand accumulations.

Examination of the building material of the different terraces has shown that the upper portion is dominated by light brown cross bedded sands (hardened dunes) with thin intercalations of yellow silt. These are underlain by an alternating series of sandstones (occasionally cross bedded) and yellow calcareous clays which appear on the escarpment

of the middle level of Wadi El Arish. Eventually, the lower portion is characterized by the occurrence of gravel bands (usually in the form of lenses; thickness ranging from few centimetres to few metres) and coarse sandy series; clay bands are rare. Data obtained from wells dug in the extreme northern portion of our area, i.e. in the vicinity of El Arish town, indicate that more gravel beds are known in the subsurface, many of which are water bearing. The gravel series are underlain by a calcareous sandy formation with abundant shell fragments. This formation is comparable to the «Kurkar» series which are known in Ghaza area where they act as the main aquifer in the coastal region. The «Kurkar» formations belong to the early Pleistocene times and are sometimes correlated with the calcareous dune ridges of the Western Desert (Picard 1943).

In our area, the Foreshore Plain is distinguished into the following morphologic features (Fig. 7 and Plate I):

a) The high plain.
b) The upper terraces of Wadi El Arish.
c) The middle terraces of Wadi El Arish.
d) The lower terraces of Wadi El Arish.
e) The present channel of Wadi El Arish and its flood plain.

We shall now proceed to deal, in some detail, with each one of these features.

a) *The High Plain.*

From the edge of the Foot-Hill Slopes of the North Sinai Upland Area, situated in the vicinity of Abu Ewigeila broken bridge at a height of 125 m., there is an extensive flat area, which could be described as a plain, sloping regionally in a northward direction, i.e. towards the present Mediterranean coast. The surface of this plain, dominated by alluvial formations, is covered by immense drift sand accumulations, which are locally developed into low lying dunes. In general, these sand accumulations make the area almost inaccessible.

This plain is dotted with few elevated points, of which Risan Aneiza, which is located in its western portion, is a remarkable feature. This plain is dissected by a number of shallow drainage lines, mainly coming

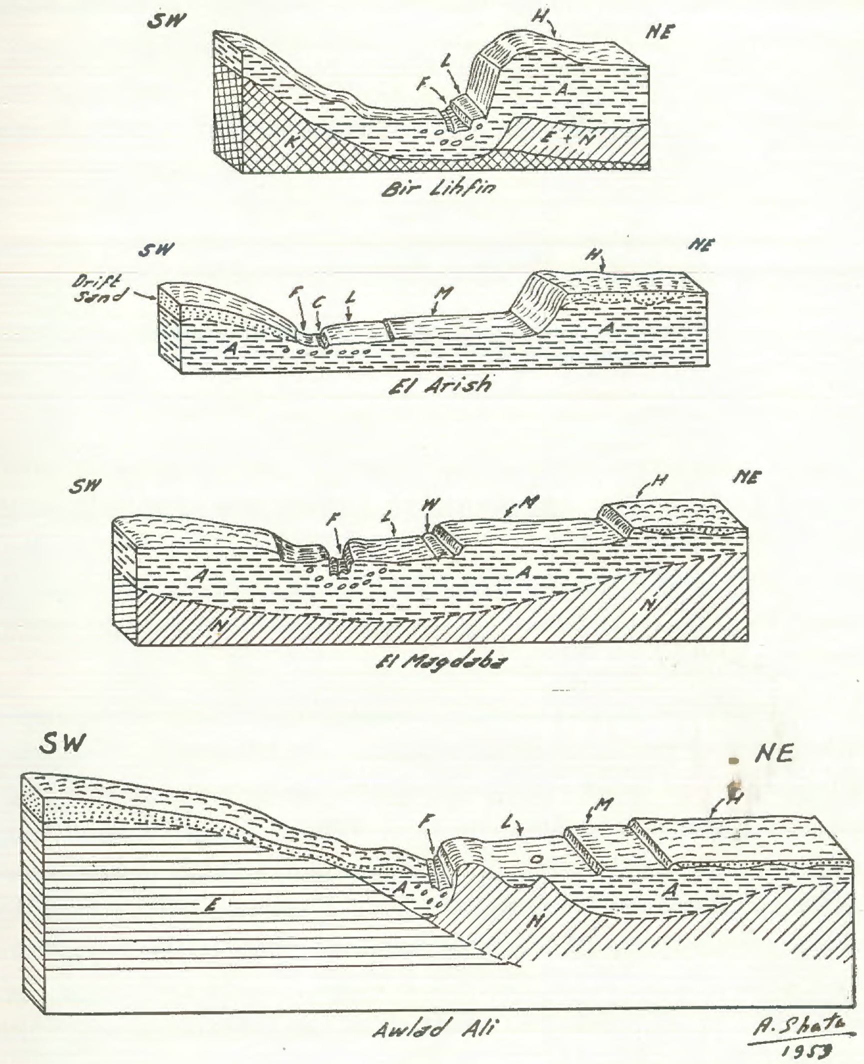


FIG. 7. Blockdiagram sections across Wadi El Arish H. High Plain; M. Middle terrace; L. Lower terrace; W. Wadi El Faheidia; F. Flood plain; C. Present Channel; A. Alluvium with gravels; E. + N. Eo-Oligocene + Neogene; N. Neogene; E. Eocene + Oligocene.

from the eastern side and joining the master stream of Wadi El Arish. Of the shallow drainage lines we mention Wadi El Faheidiya, Wadi El Hareidin and Wadi El Maazar. This last wadi, linked to the main wadi in the vicinity of El Arish town, is considered as one of the important contributors to the water supply of El Arish Basin. Another feature characteristic to the surface of this plain, is the presence of many shallow depressions (Nagâa and plural Nugûe) where local bedouin settlements and very limited cultivation of barley, are known.

The sand accumulations, covering the surface of this plain are distinguished into three main features :

1) Sand sheets having a very roughly undulating surface with little or no vegetation. These sand sheets dominate the whole plain and are particularly noticeable in the southern portion (El Hamza).

2) Crescendic sand dunes having a low relief, and are mainly oriented in a NW-SE direction and with their leeward side essentially facing southwest. These dunes have a wide distribution in the northern portion of the plain, but few of them are reported many kilometres inland. Of these, Katib El Teir, situated on the latitude of El Magdaba, is a good landmark of the high plain.

3) Complicated sand dunes which arrange themselves in a conspicuous belt having a width varying from one to two kilometres. This belt, extending almost to Ghaza, runs parallel to the coast and rises in some places, more than 35 m. above sea level. It contains many shallow water wells (Thamila and Thamaeil) which give a limited supply of fresh water suitable for localized cultivation.

When considering the regional northward slope of the high plain, we have already mentioned that the rates are of the order of 2 m./km. We might as well draw the attention to the following points which appear to be interesting :

1) In the Lihfin area, the high plain maintains a local, but a rather conspicuous rise in its relief. This rise is particularly noticeable in the eastern side of the wadi and is obviously related to the NE-SW domal structure of Risan Aneiza affecting the subsoil. We expect this domal structure to have played a part in the development of the Lihfin gorge

into which the wadi, in some older periods was choked and thus allowing some of its burden to be laid down. We also expect this domal feature to allow the land surface to rise, of course, due to tectonic activity along the axis in the Quaternary times.

2) From Lihfin northward, the slope of the high plain is not regular but it shows a series of steps facing the north and running in an east-west direction, i.e. parallel to the present Mediterranean coast. These steps occur at variable distances from the present coast line. The altitudes of the most remarkable ones are 82 m., 60-55 m., 35 m. and 12 m. above the present sea level. Although we are not well informed about the actual characteristics of these steps, because of the lack of detailed investigations, we may be justified, on basis of their morphological appearance, to mention that they represent the successive stages in the lowering down of the Mediterranean relative to land; a process which took place in Pleistocene and Holocene times. These steps may mark also the approximate position of the Mediterranean shore lines during the Sicilian, Melazzian, Tyrrhenain and eventually Monastirian (Fig. 8).

The levels of these successive stages may be correlated with those suggested by Dépéret in Algeria (1918), to less extent with those of McBurney in Libya (1955), and those of Philip in Egypt (1955). The following table gives the comparative elevations of some Mediterranean levels in North Africa and the corresponding levels in Sinai :

Age	Algeria (Dépéret)	Cyrenaica (McBurney)	Mariut, Egypt (Philip)	Sinai, Egypt (Shata, 1959)
Sicilian	90-100 m	70-90 m	80 m	82 m
Melazzian.....	55-60 m	44-55 m	60 m	55-60 m
Tyrrhenian ...	28-30 m	38-40 m	35 m	33-35 m
Monastirian ..	18-20 m	18-25 m	15 m	12-22 m?

The elevations given for the Sinai area correspond more or less to the different levels in the Western Desert.

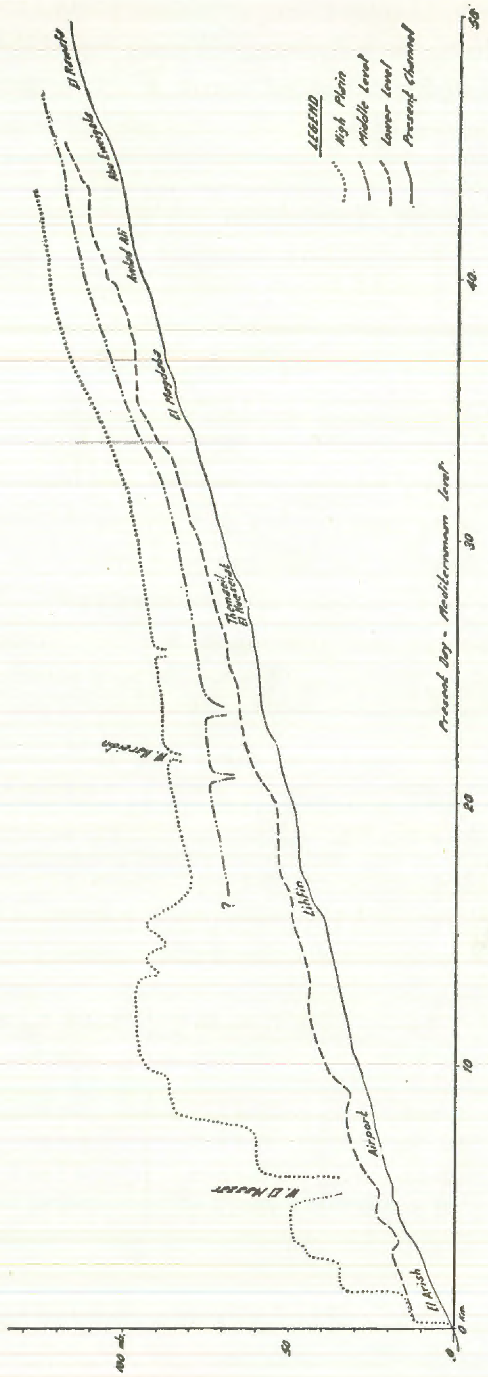


Fig. 8. Longitudinal section along the different levels of Wadi El-Arish.

b) *The Upper Terraces of Wadi El Arish.*

The present channel of Wadi El Arish is bounded on both sides, by three main terraces representing the successive stages in its evolution during the Holocene times. The uppermost terraces rise 33 m. above the present channel and along them the old wadi was more than eight kilometres wide. On the approach to the Lihfin gorge, the width is reduced to less than two kilometres. From Lihfin northward i.e. in the downstream direction, the old wadi widens again a maximum of 4 kms. in the vicinity of El Arish town.

On the eastern side of Wadi El Arish basin, it is possible to trace this upper terrace for a rather long distance extending from the neighbourhood of the Abu Ewigeila broken bridge almost to the entrance to the Lihfin gorge. This terrace forms a low lying escarpment rising about 10 m. above the middle terrace and its position can be fixed by a remarkable line of dune ridges following its edges. These are particularly noticeable in the region east of El Greie (Katib El Teir is a well known dune and forms a good landmark rising more than 20 m. above the surrounding plain). On the other side of the wadi, we were unable to trace this level for any considerable length. This was due to the occurrence of a blown sand cover. However, we are informed from the characters of the contour lines that this terrace is possibly running underneath the sand cover in a direction parallel to the present channel and not far away from it. Nevertheless, we are not certain whether it continues to the slopes of Risan Aneiza upland or it becomes eroded by the effect of Wadi El Hassana which may be joining wadi El Arish master stream from the western side.

From Lihfin northward, differentiation between the upper and middle terraces of wadi El Arish is practically impossible. Both are linked to form a low lying escarpment which bounds the present wadi depression and is there densely covered with drift sand. Comparing this side of Wadi El Arish to the western side, which is also densely covered with drift sand, it is noted that the eastern side is quite smooth, and in the vicinity of El Arish town it is broken by the gate of wadi El Maazar. On the other hand, the western side is irregular and there is no doubt that

it has been affected by a number of lateral subsequents originating from the Risan Aneiza upland area. These lateral subsequent wadis are almost hidden underneath the sand cover but there is reason to believe that some of them join the main wadi and are accordingly considered as the main contributors of the water supply of El Arish basin.

Wherever exposed, the building material of this upper terrace is almost uniform and is composed of a medium hard quartz sand series having a brownish colour and yielding no fossils. This sand formation is commonly cross bedded and is locally intercalated with very thin laminae of fine silt. The rough mechanical analysis of samples collected from this formation shows that the sand grains are well sorted and from their size measurement a dune origin may be assigned to them. The occurrence of such dune sand formations indicate a prevailing dry climatic conditions in Holocene times. The thin silty layers may, on the other hand, indicate the short wetter periods taking place during the same times.

We might as well refer to the fact that the building material of this upper terrace, which also constitutes the surface layers of the high plain, has a considerable porosity and we expect that certain amounts of the water resulting from the annual rain (average 100 m./annum or 100,000 cu.m./sq.km.) would percolate through the sandy formations where it would be perched on one or more of the impervious silty layers. Similar cases are apt to occur in the formations constituting the middle terrace. Again, with the regional northward slope, some of the percolating water would move freely to find its way into one or more of the local reservoirs which are associated with the porous «kurkar» formations. These are present in the form of burried ridges dominating the coastal strip and extend from El Arish to Rafah. We expect also some subsoil drainage lines, traversing the foreshore plain in a direction parallel to Wadi El Arish and Wadi Ghaza i.e. in a northwest direction which would feed the reservoirs already referred to. There is no doubt that one or more of the subsoil drainage lines join Wadi El Arish master stream to the north of Lihfin and may be considered as contributors to the water supply of El Arish basin.

c) *The Middle Terraces of Wadi El Arish.*

The middle and lower terraces of Wadi El Arish are easily recognizable compared to the upper ones which are partly or totally masked underneath a mantle of drift sand. These two terraces are represented by low lying escarpments occurring at variable distances from the present channel of Wadi El Arish, but both keep at a uniform height from it.

The middle terrace is situated at a height of about 20 m. above the present channel and is traceable from the vicinity of Abu Ewigeila broken bridge almost to the upstream portion of Lihfin gorge. From this gorge northwards this terrace could not be differentiated from the upper terrace. This terrace slopes in a northward direction at the rate of more or less 2 m./km. (a drop of 100 m. over a horizontal distance of 50 km.). This amount is comparable to that of the upper terrace in the same region (Fig. 8). Local changes are apt to occur. For example, in El Greie and El Shiha extensive areas, lying south of Lihfin, the northward gradients are reduced to about one metre per kilometre (a drop of 15 m. over a distance of 15 km.). This extensive area (not less than 10,000 feddans) is almost flat and is crossed in an east-west direction by the shallow basins of Wadi El Hareidin and Wadi El Greie. These two wadis join a longitudinal subsequent stream by the name of Wadi El Faheidia, which has its intake portion situated at Rie Abu Widan lying to the north of El Magdaba and then runs in a north-west direction at the foot of the scarp made by the middle terrace. Eventually it joins the master stream of Wadi El Arish at a point lying a short distance south of Lihfin gorge.

The geological succession represented in the middle terrace of Wadi El Arish is composed of an alteration of sand and clay beds having an average thickness of 10 m. The sand beds are usually cross bedded and have a thickness ranging from half a metre to few metres. The clay beds are less developed and their individual thicknesses rarely exceed one metre. The basalt beds in this succession are composed of coarse brown sandstone having a thickness of about three metres and continue downwards into the succession of the lower terrace. On top, this terrace is dominated by alluvium and clay beds which are occasionally mixed with varying

quantities of drift sand. These constitute the type of soil common to El Greie and El Shiha extensive areas. No fauna were reported in the samples collected from this succession and the mechanical analysis of some sand samples revealed a dune origin of the layers from which they were taken. The arrangement of the cross bedded sand layers, having a dune origin and the yellow clay beds may indicate a fluctuation of the climatic conditions which prevailed during the late Pleistocene times. This condition differs from that which took place during the deposition of the upper terrace in Holocene times where the succession is dominated by sands of dune origin and little or no clay beds.

d) *The Lower Terraces of Wadi El Arish.*

The lower level of Wadi El Arish forms a remarkable feature in the foreshore area of north-east Sinai. It has been followed at a uniform height of more or less 10 m. above the wadi floor from the vicinity of El Rawafa Dam to Abu Sagal along the Mediterranean coast i.e. over a distance of 50 km. At Abu Sagal, which is situated east of El Arish town, this lower level is developed into a low lying cliff rising 12 m. above the present sea level. This cliff lies 100 m. south of the present Mediterranean coast, and runs parallel to it i.e. in an east-west direction, and may mark the position of the Mediterranean in pre-Roman times (Late Monastirian). Moon and Sadek (1921), referred to the occurrence of a raised beach in the vicinity of El Arish town. Although the authors did not describe the actual location of this beach we are inclined to believe that it may be in alignment with the low cliff occurring at Abu Sagal.

Along this lower level, Wadi El Arish has an irregular width varying from 100 m. to more than 1500 m. On this level the wadi forms several conspicuous meanders which are particularly noticeable at Abu Ewigeila, El Magdaba, Lihfin, El Hinwa and eventually El Arish. On both sides of the present channel there are vertical cliffs having an average height of 10 m. which mark the edge of that level. Within these cliffs, minor terraces occurring at 2.0 m., 3 m. and 3.5 m. above the present channel are distinguished. Of these minor terraces the one occurring at 2 m. is quite prominent and forms local isolated islands within the wadi depression. These are known to us, at intervals from Abu Ewigeila almost to El Arish town.

On the eastern side of the present channel of Wadi El Arish, this lower level is dissected by a number of small lateral subsequents (Dakhakhin, El Faheidia and others) whereas the western side is partly or totally covered with drift sand. These lateral wadis, receiving some water during the rainy seasons, have some effect on the landscape. Among the features characteristic to this side is the occurrence of the extensive sheets of mud flats which dominate the top portion and which slope in a northward direction at the rate of more or less 1 m./km. The surface of these mud flats is almost barren from vegetation. However, local cultivation, mainly barley and olives, is noted. In the southern portion i.e. in the area around Awlad Ali, the surface is dotted with gravel knobs which are undoubtedly part of the gravel series constituting this level. In the area extending from Rigm El Hor to Wadi Hareidin, superficial gravel knolls are noted and are thought to be younger than those of Awlad Ali. These gravels were either derived from a pre-existing gravel body or from the Eocene flinty chalk formations constituting the plateau of Gebel El Wogeir lying to the south-east of our area. Where not covered with the young alluvial deposits, the altitude of this level is sometimes reduced to less than 8 m. above the present channel of the wadi. This may be due to the local water erosion. The effect of water erosion is also felt in the irregular and rough appearance of this level where there are enumerable short and steep gullies.

As far as the western side is concerned, drift sand accumulations, which are locally covered with Tamarix trees, are present. In some places, namely at Thamayel El Nueseiat, El Hamza and also in the area lying to the north of Bir Lihfin, the lower terrace is completely masked underneath these deposits. In general, the effect of water erosion is not apparent on this side. It is only felt in the form of very short lateral subsequents which are particularly noticeable in the vicinity of Risan Aneiza upland area.

Examination of the building material of this lower level indicates that it is essentially formed of alternating gravel and coarse sandstone series which are interbedded with thin laminae of yellow calcareous clay.

The sand and gravel layers are present in the form of lenses. The succession is covered on top by a modern alluvium series. At Awlad Ali an older gravel series is exposed on the eastern side of Wadi El Arish and can be differentiated easily from the modern ones. Below these young gravels more gravels are known. These are reported in some water wells and show a maximum development of 35 m. (Desert Irrigation wells at El Arish). Some of these gravels are water bearing (Fig. 9). These gravels are underlain by a coarse grained calcareous sandstone series which are comparable to the «kurkar» formations known in the coastal area of Palestine. These constitute one of the main water bearing formations in the area. The «kurkar» formations, belonging to the Lower Pleistocene times, are confined to the coastal strip (extending inland for about 7 km.) and do not appear on the surface in the Sinai area. They are only reported in the subsurface and are completely covered by the alluvial and diluvial deposits (Late Pleistocene) and by aeolian sands (Holocene).

e) *The Present Channel and the Flood Plain.*

The last feature existing in the foreshore area is the present channel of Wadi El Arish and its flood plain which rises more or less 2 m. above it. This channel has a width varying from few metres to more than 50 metres and slopes regionally in a northwards direction at the rate of 2 m./km. (Fig. 8). Local changes are present and are either due to the geological structure, the type of exposures or the connection of the master stream to any of the lateral subsequents.

The bed of the present channel is composed of a variety of rock formations. These include the following :

1) The Eocene flinty chalk series which are known at El Rawafa and extend to Abu Ewigeila. Steep gradients of the wadi are noted in this particular portion. The Eocene series are covered with a mantle of loose gravels and alluvium which have variable thicknesses. Limestone boulders, derived from the Eocene series, are not uncommon.

2) The Miocene marls and Pliocene conglomerates which are known at Awlad Ali. These are also covered with loose gravels and alluvium.

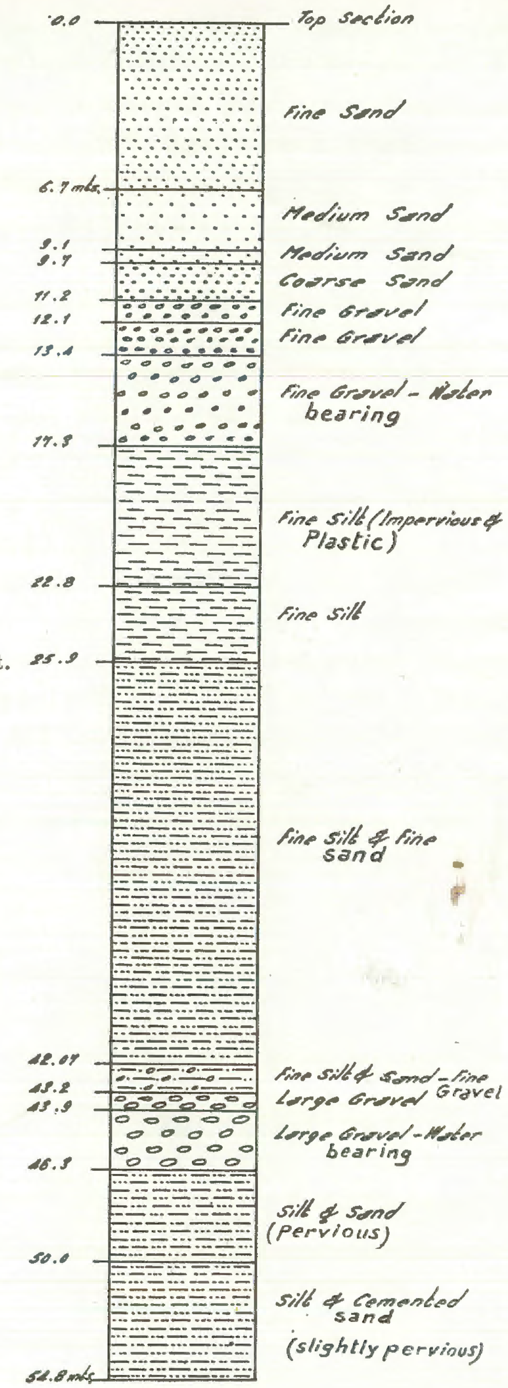


FIG. 9.
Columnar Section,
El Arish Well No. 1
of the Desert Irrigation Dept.

3) The hard conglomerates of Pliocene age which appear at El Magdaba. These are also covered with a mantle of recent gravels, silt and sands.

4) The alluvial and diluvial deposits of the wadi itself which are composed essentially of gravels and alluvium and are mixed with drift sands. These are particularly noticeable in the northern half. The gravels vary from coarse, in the southern portion, to fine, in the north.

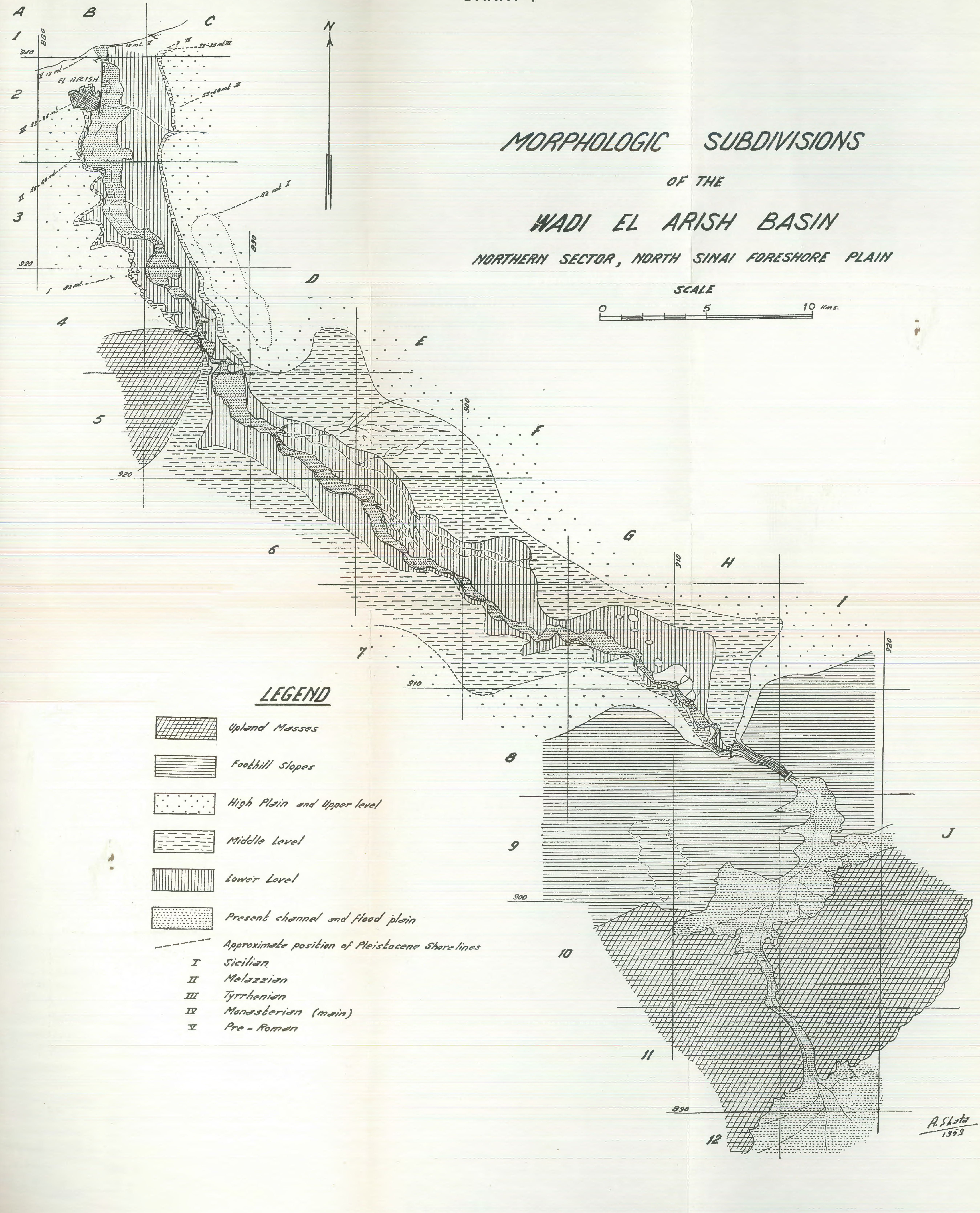
From El Rawafa northward, the present channel of wadi El Arish is crossed by a number of earth dykes. These are made by the local bedouins in connection with both soil and water conservation. At El Rawafa, there is a narrow and a rather short gorge bounded by the Eocene flinty chalk and limestone series. At this site a concrete dam was made in 1947 with the object of holding the flood water of Wadi El Arish which is thought would be utilized for agricultural expansion. Unfortunately no expansion was attained, but on the other hand, this dam, which is rapidly silting up, held some water which at one time was mainly used for military purposes.

Still remains few words to be mentioned about whether Wadi El Arish has degraded its valley to depths lower than the present channel or not. Facts from the wider region make us assume that during the late Palaeolithic times (Monastirian) the wadi has lowered its channel by erosion and then raised it again by deposition. Estimation, however, of the heights and slopes of the flood plain in periods when the wadi was lowering its valley is rather difficult.

REFERENCES

1. Awad, Hassân (1951). La Montagne du Sinaï Central, *Étude morphologique,* Le Caire, 247 p.
2. Ball, J. (1939). *Contribution to the Geography of Egypt.*
3. Beadnell, H. J. L. (1921). The Wilderness of Sinai. *A record of two years recent exploration* (Ed. Arnold and Co.).
4. Blake and Goldschmidt's (1947). *Geology and Water Resources of Palestine,* Jerusalem.
5. Dépéret, C. H. (1918). Essai de coordination chronologique générale des temps Quaternaires, *C. R. Acad. Sci.* Paris.
6. El Gabaly, M. (1954). The Soil, Water Supply and Agriculture in Northeast Sinai, *Bull. Inst. Desert,* T. IV, No. 1, Cairo.
7. George, F. (1955). Geology of the Pleistocene Sediments of the Mediterranean Coast West of Abu Qir. *A Ph. D. Thesis,* Cairo Univ.
8. Hume, W. F. (1925). Geology of Egypt : Vol. I, The Surface Features of Egypt. *Surv. of Egypt,* Cairo.
9. McBurney, C. B. M. and Hey, R. W. (1955). Prehistory and Pleistocene Geology of Cyrenaican Libya. Cambridge University Press.
10. Moon, F. W. and Sadek, H. (1921). Topography and Geology of North Sinai : Part I. *Bull. No. 1,* Cairo.
11. Paver, G. L. and Jordan, J. N. (1956). Report on Reconnaissance Hydrological and Geophysical Observations in North Coastal Area of Egypt. *Bull. Desert Institute,* No. 7, Cairo.
12. Picard, L. (1936). The Geology of the Ghaza Beersheba Plain. *Bull. Geol. Dept. Hebrew,* Univ. I, Jerusalem.
13. —— (1943). Structure and evolution of Palestine with Comparative notes on the Neighbouring countries. *Bull. Geol. Dept., Heb. Univ.,* Jerusalem.
14. —— (1951). Geomorphogeny of Israel Part I, The Negev. *Bull. Research Council of Israel,* Vol. I, No. 1 and 2.
15. Sadek, S. (1926). A Scientific Study of Scenery in Sinai. *C. R. Congr. Intern. Geogr.,* Le Caire, Sess. XI, 1925, T. III.
16. Shata, A. (1957). Remarks on the Physiography of El Ameria-Mayiut Area. *Bull. Geogr. Soc.,* T. XXX, Cairo.

CHART I


MORPHOLOGIC SUBDIVISIONS
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NORTHERN SECTOR, NORTH SINAI FORESHORE PLAIN
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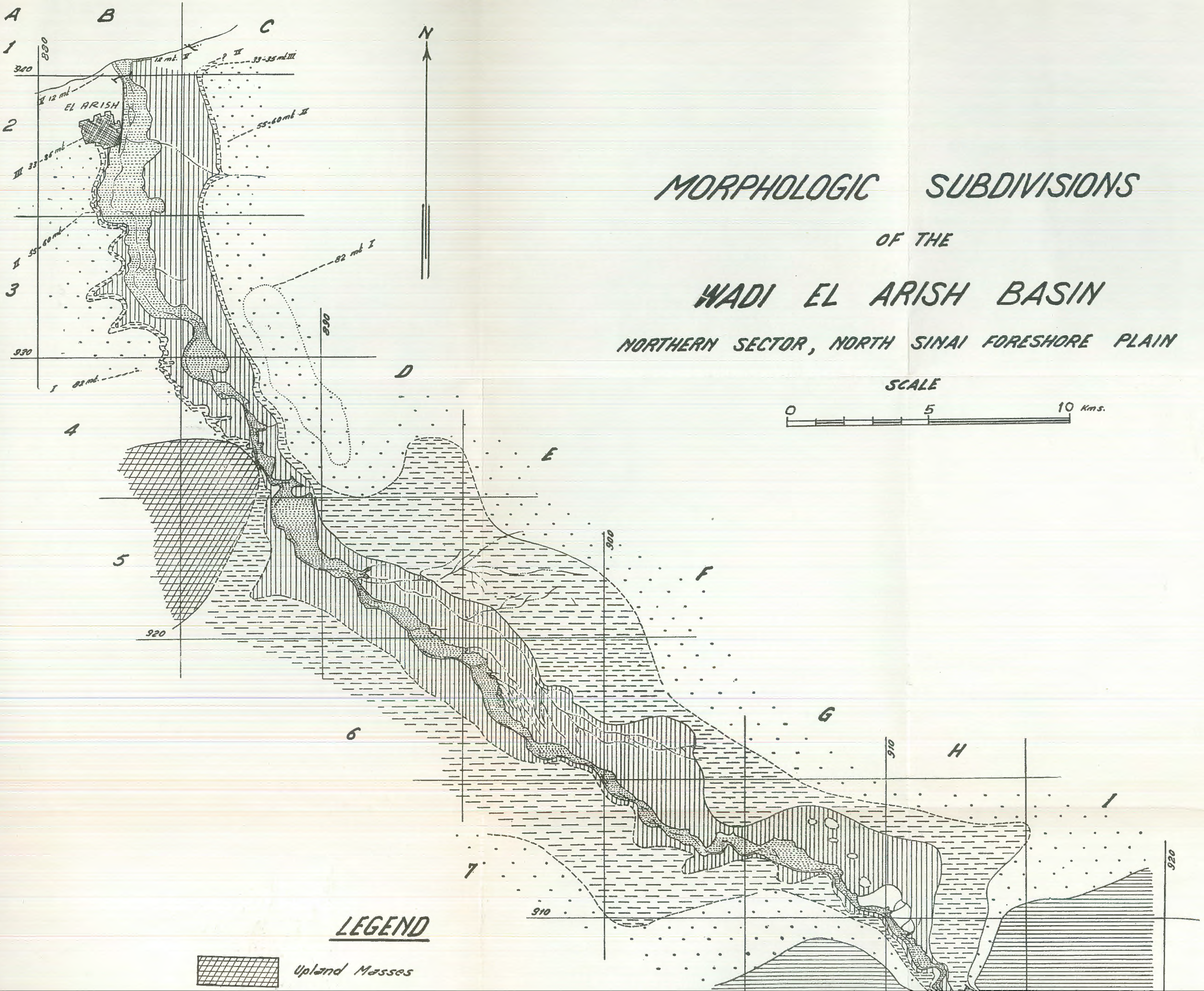
11
12
LEGEND
Upland Masses
Foothill Slopes
High Plain and Upper level
Middle Level
Lower Level
Present channel and flood plain
Approximate position of Pleistocene Shorelines
I Sicilian
II Melazzian
III Tyrrhenian
IV Monasterian (main)
V Pre - Roman
A. Shata
1953

CHART I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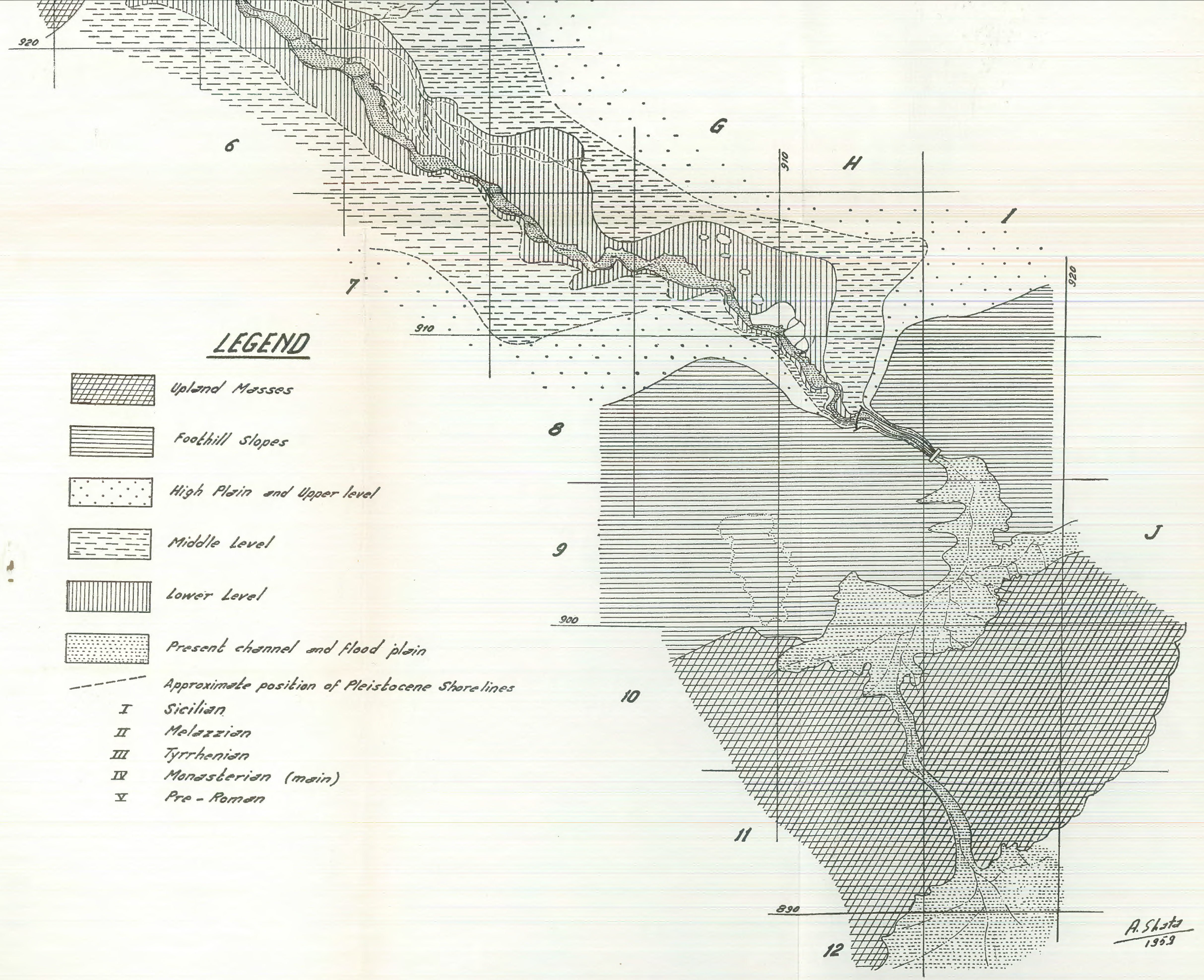
LEGEND
Upland Masses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High Plain and Upper level
Middle Level
Lower Level
Present channel and flood plain
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III Tyrrhenian
IV Monasterian (main)
V Pre - Roman
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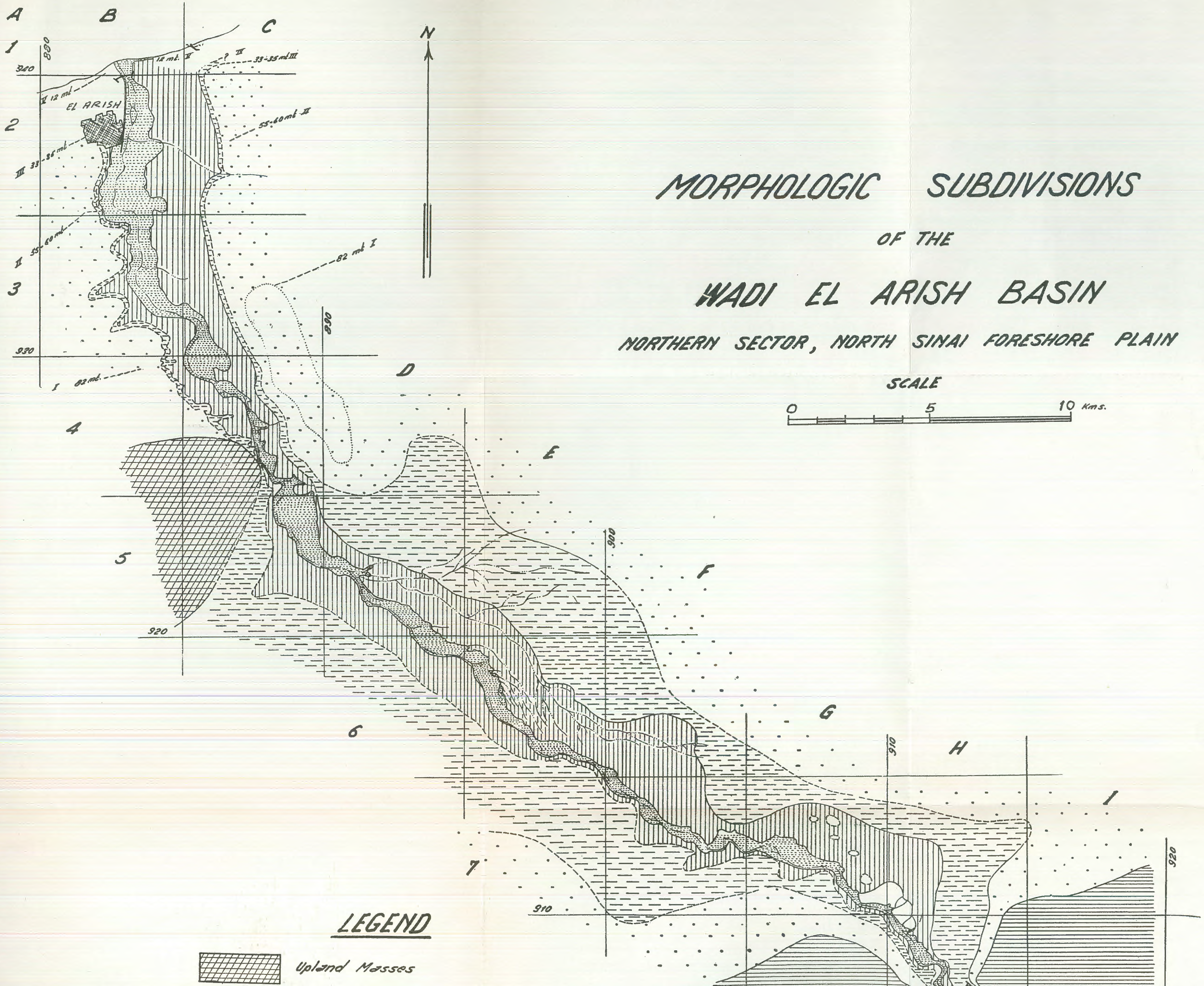
A. Shata
1959

CHART I



MORPHOLOGIC SUBDIVISIONS
OF THE
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NORTHERN SECTOR, NORTH SINAI FORESHORE PLAIN
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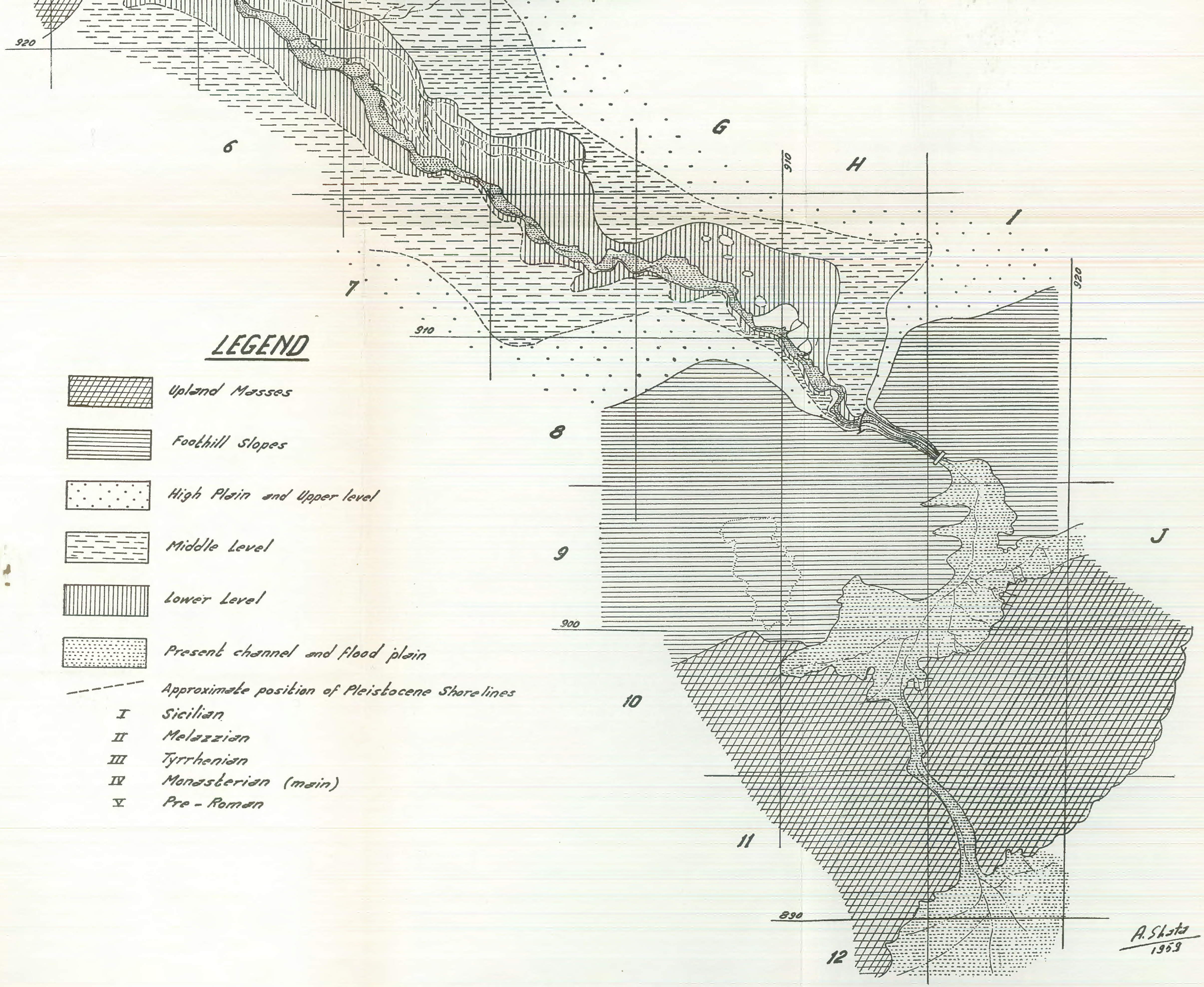
LEGEND
Upland Masses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LEGEND
Upland Masses
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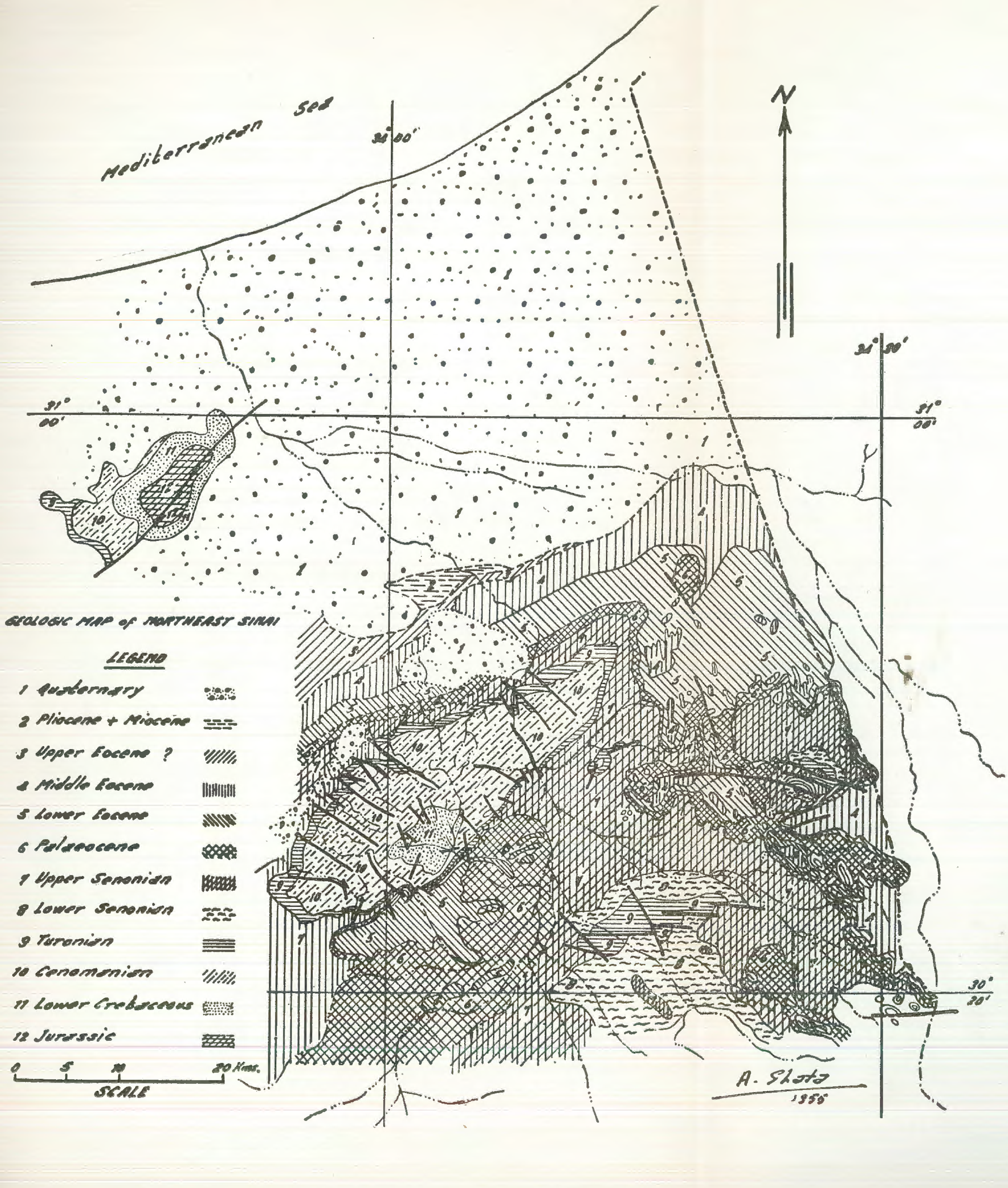
1959

CHART II


Mediterranean Sea
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30° 30'
GEOLOGIC MAP of NORTHEAST SINAI
LEGEND
1 Quaternary
2 Pliocene + Miocene
3 Upper Eocene ?
4 Middle Eocene
5 Lower Eocene
6 Palaeocene
7 Upper Senonian
8 Lower Senonian
9 Turonian
10 Cenomanian
11 Lower Cretaceous
12 Jurassic
0 5 10 20 Kms.
SCALE
A. Shata
1956

GEOLOGICAL PROBLEMS
RELATED TO THE GROUND WATER
SUPPLY OF SOME DESERT AREAS OF EGYPT

BY

A. SHATA

Geological investigations in some selected desert areas of Egypt have been carried out lately with the object of collecting information about the factors influencing their soil and water supply. The following are the areas which, so far, have received special attention :

1. El Ameriya-Mariut Area to the west of Alexandria.
2. Wadi El Natrun-Liberation Province Area on the western marginal portion of El Delta Basin.
3. El Kharga and El Dakhla Oases in the southern portion of the Western Desert.
4. Wadi El Arish Basin in the foreshore area of North Sinai.

To these four areas we shall add Ghaza Strip in Palestine.

I. EL AMERIYA-MARIUT AREA

In this area, which constitutes a portion of the foreshore plain west of the Nile Delta, the landscape is essentially a series of elongate ridges (ancient consolidated dunes formed along a receeding shoreline in Pleistocene and Holocene times—Shata, 1957) which are oriented in a NE-SW direction. These ridges alternate with shallow and elongate depressions. The ridges have elevations varying between 10 m. (above seal level) for the modern ones and 35 m. for the old ones. The depressions are mostly near sea level and are filled with salt marshes which are underlain by a marine limestone bed containing *Cardium edule* (lageonal deposits are occasionally present). The southern portion

of El Ameriya-Mariut area is a slightly elevated plateau (Mariut Tableland, + 100 m.) which descends gradually in a northeast direction i.e. towards the Delta Basin, and is dissected by a shallow consequent valley (Abu Mina) draining into the « Mallahet Mariut Area »—Shata, 1957.

On geological basis, the surface of El Ameriya-Mariut area is occupied by young Neogene and Quaternary sediments having a thickness much less than a 100 m. These are all dominated by lime facies. In the depression areas, lagoonal deposits (alternating gypsum and clays) are locally known. The geological structure of this area is rather simple. Regionally, it occupies a portion of the main « Marmarican » homocline (extending from Cyrenaica to the Nile Delta and from the Qattara-Siwa Depressions to the Mediterranian-Mitwally, 1953) and shows a low northward dip-Shata, 1957. Minor east-west faults are apt to occur and have their downthrow side situated to the north. In the subsurface, the geological structure is rather complicated-Shata, 1953. The geophysical investigations which were made by the Petroleum Companies have revealed a number of major anticlinal axes which are all oriented in a NE-SW direction. Some of these anticlines were tested for oil, but the results were not successful (At Burg El Arab a bore hole was put down to a depth of about 14,000 ft. by the SPC [1]).

The study of the physiography of El Ameriya-Mariut area was made in 1957. When carrying out the field work, the occurrence of a conspicuous closed topographical basin beyond the oldest ridge (Gebel Mariut) in the region lying between Bahig and El Hammam, drew the attention of the present writer. This basin has a length from NE to SW, of about 13 km. and a width from NW to SE, of 5 km. It occupies, therefore, an area of about 65 sq.km. (+15,000 feddans) and its surface elevation is generally lees than +10 m. Its lowest portion (±5 m. above sea level) is present in close proximity to Burg El Arab. The surface portion of this basin is essentially occupied by a loamy soil formation which in some places attains a vertical thickness of more or less 7 m. These are underlain by a lagoonal series (gypsum and clays) and/or an oolithic limestone formation (Figs. 1 and 2).

[1] SPC : Sahara Petroleum Company.

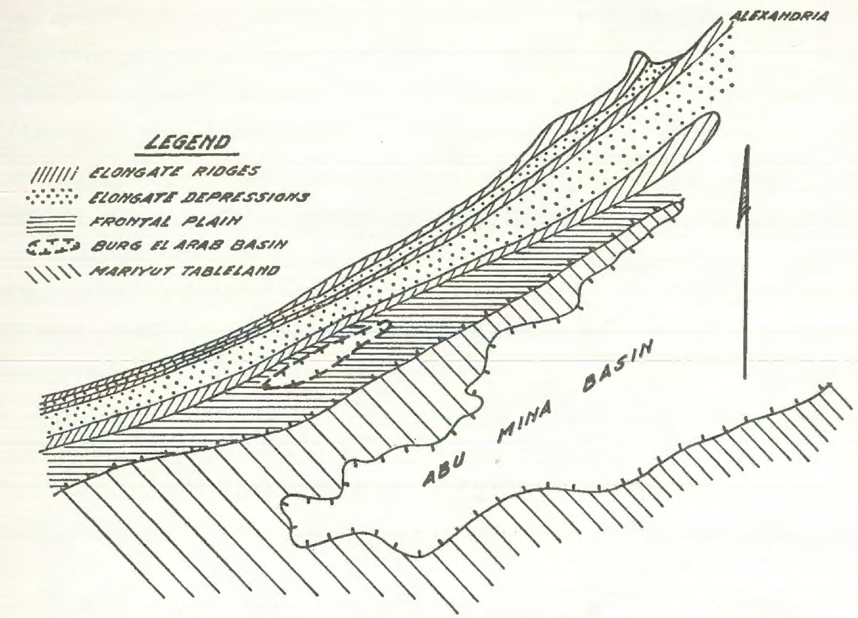

FIG. 1. Physiographic Map of El Ameriya-Mariyut Area.

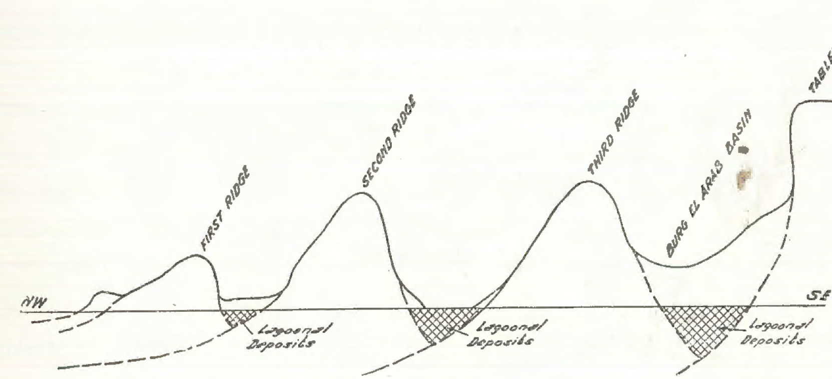

FIG. 2. Diagrammatical Section Acros Burg El Arab Basin.

In the foreshore area of Egypt's Western Desert, there is a main water table occurring at about sea level (Hume, 1925). However, in some places, local basins are developed, where considerable quantities of water are obtainable. Of these « Basinal Areas » reference will be given to that closed basin occurring at Burg El Arab. According to Paver and

Pretorius, 1954, the large yields which are obtained from this basin are due to an «unusual condition», where the local ground water supplies «are being augmented by lateral seepages from the Delta». From our observations, we feel that the local topographical conditions together with the local rainfall are fully responsible for this good yield of water. To these factors we may add another one concerning the occurrence of the impervious gypsum beds at the bottom of this basin. In this area, we expect that the water which is annually drained into this basin, both from the «Mariut Tableland» and from Gebel Mariut Ridge, would accumulate on top of the «lagoonal beds» and cause this local rise of the ground water table.

II. THE WESTERN MARGINAL PORTION OF THE NILE DELTA

Of this wide area, the region extending from the Liberation Province westward to Wadi El Natrun Depression (50 km. wide), received some attention owing to its ground water possibilities. On the south, this region is bounded by Wadi El Farigh Depression and on the north it merges into the «Mariut Tableland». In this region, the highest point (+117 m.) is situated in its southern portion and the lowest point (+32 m.) occurs in the far northern side (10 km. to the north of Bir Victoria). There is accordingly a difference of relief of 85 m. The surface is very gently undulating and shows a regional slope in the northward direction. As regards the relationship between this region and the Delta Basin, there is a striking geographical contrast.

Between the Delta Basin and Wadi El Natrun, the surface is essentially occupied by coarse and fine gravels (These are described by Sandford and Arkell, 1939 as Nile gravels belonging to different terraces and occurring at different heights. Their age is essentially Pleistocene). In the northern portion, the gravel series are overlain by drift sand accumulations. At the approach to Wadi El Natrun and to Wadi El Farigh, the Pleistocene gravels are underlain by the marine and estuarine Pliocene deposits. These are composed of porcellaneous limestones with tabular flint, and calcareous sandstones. With these are associated «fluvial

gravels and conglomerates». In the Wadi El Natrun Depression, Lower Pliocene clays are reported (Hume, 1925). In the shallow wells (±100 m. deep) drilled to the cast of this depression the succession (belonging to the Pliocene) is composed of alternating sandstones and dark grey clays; limestones beds are rare. In a deep test well for oil drilled by SPC in the depression itself, the Pliocene series has a thickness of 200 m. and is underlain by a Miocene section (shallow water marine facies and deltaic beds) which has a thickness of 300 m. The Miocene beds are underlain by a Basalt sheet; ± 20 m. thick, having an acceptable Oligocene age).

In the area west of the Nile Delta, the regional structure is a low northward dip on the flanks of El Marmarica main homocline. This simple picture is complicated by folding, faulting and basalt eruptions which appear to have affected the physiography of the area (Fig. 3).

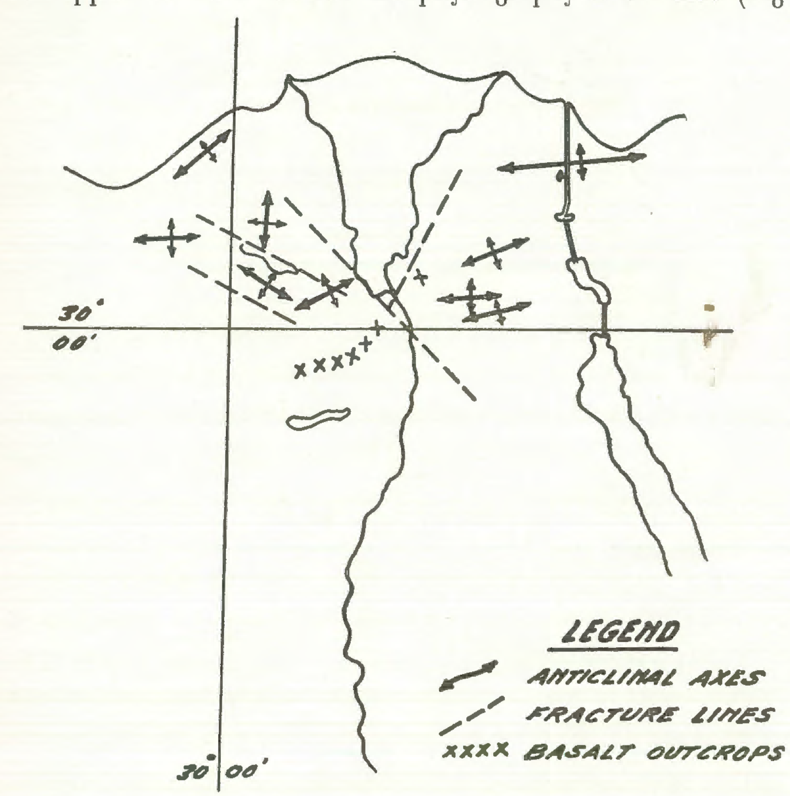

FIG. 3. Map to show complicated geological structure Bounding Delta Basin.

The dominant structural trend is a NW-SE one which is parallel both to Wadi El Natrun and to Rosetta Branch of the Nile (At Abu Roash and Wadi El Farigh the structural axes are exceptionally oriented in a NE-SW direction). The faults bounding the Delta Basin give it the nature of a «graben» (Fig. 4).

As far as water is concerned, the Neogene and Quaternary succession (±500 m. thick) which overlie the Oligocene Basalts is considered as

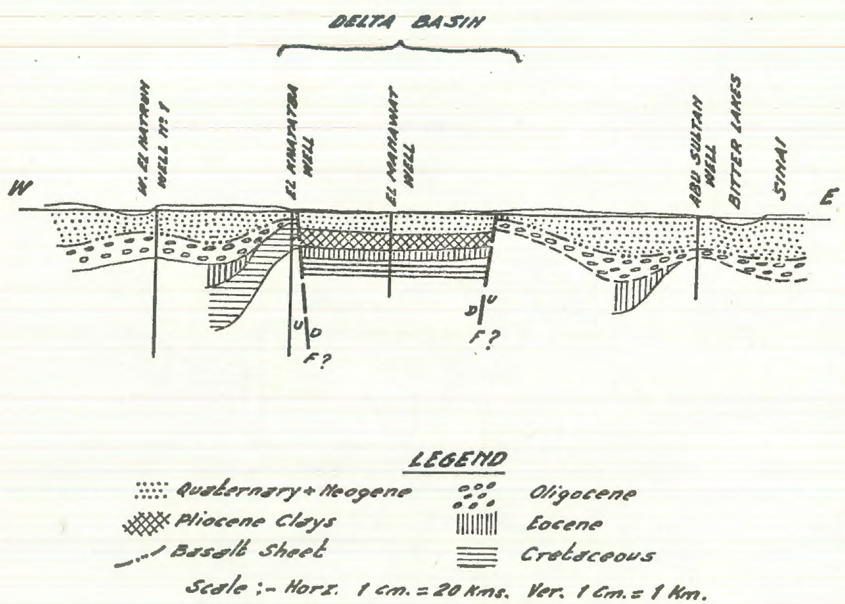

Fig. 4. East-West section across the Delta Basin.

an excellent acquifer (The Nile Basin is regarded as the main source of water derived from this area). The complicated geologic structure of this area has undoubtly affected the distribution of this acquifer. But not only this, the relationship between this acquifer and the source beds below the Delta Basin is also affected. As shown in Fig. 4, this relationship is fault determined. However, the occurrence of a rapid flexure is not impossible. Solution of this specific problem has to wait the analysis of the geophysical data collected from the marginal portion of the Delta Basin.

In the western marginal portion of the Delta Basin, attempts to exploit the ground water for the purpose of agricultural expansion, was made in three main districts; namely the Liberation Province, the strip of land along the Cairo-Alexandria Road between km. 86 and km. 110 (from Cairo) and eventually the Wadi El Natrun Depression. This work has not been preceeded by geological and hydrological investigations of any considerable length. It is not surprising, therefore, that some of wells which were put into production became suddenly deplected.

Early this year, the Desert Institute has received the rock samples which were obtained from the shallow wells now put down in the area adjacent to the Cairo-Alexandria Desert Road. Examination of these samples from points of view of their lithology, heavy mineral and faunal content, and rock texture is now made with the object of making local correlations on basis of which the subsurface conditions (mainly geologic structure and facies characters) can be delineated. Attempts to extend our correlations to include the wells of Wadi El Natrun and those of the Liberation Province are intended. It is hoped that the results of this work will be tied, in the near future, to those which will be obtained from the deep bores now sunk in the Delta Basin.

III. EL KHARGA AND EL DAKHLA OASES.

El Kharga and El Dakhla Oases of the Western Desert of Egypt occupy «an immense natural excavation in the Libyan Desert Plateau». The eastern part of this excavation is situated about 150 km. west of the Nile Valley. El Kharga Oasis, nearest to the Nile Valley, is oriented in a N-S direction while El Dakhla (inner oasis) runs in a WNW-ESE direction and both are separated by a dividing ridge which is rather broad (±200 m. above sea level). The floor of these two oases lies in most part at about 350 m. below the calcareous plateau which bound El Kharga mostly on the eastern side and El Dakhla mostly on the northern side, and is separated from by a «bold and precipitous escarpment». In the central portion of El Kharga Depression the ground elevation is generally below +100 m. (lowest point, +1.7 m. occurs in the area lying to the east of Bulaq Village) whereas in El Dakhla it is generally

above + 100 m. El Kharga Depression is dotted by a number of isolated hills (mostly associated with the local geologic structure). In El Dakhla on the other hand only one isolated hill is known and represents « a detached portion or outlier of the plateau and lies about 17 km. west of Qasr». The floor of El Kharga Depression is differentiated into two portions; a central portion occupied essentially by lacustrine deposits and a marginal portion dominated by drift sand, gravels and copples. The floor of El Dakhla Depression « consists chiefly of red clay» belonging to the Cretaceous period, « covered in many parts by alluvium», « it is divisible into two cultivated areas by a strip of barren desert about 10 km. in width».

In El Kharga and El Dakhla Oases, the exposures are totally composed of sedimentary rocks belonging to the Secondary and Tertiary eras and have a thickness of about 500 m. (young Quaternary deposits are also present but they are essentially restricted to the depression floors). The ages of the occurring groups are as follows :

4. Lower Eocene series; dominated by limestone and chalk facies (±200 m. thick).

3. Palaeocene series; dominated by shale facies (± 50 m. thick).

2. Upper Senonian series; dominated by limestone, chalk and shale facies ± 100 m. thick.

1. Lower Senonian to Cenomanian? series; dominated by phosphate, red clays and Nubian type sandstone facies ± 400 m. thick.

In the subsurface, the succession is composed essentially of Nubian type sandstones, conglomerates and siltslones, belonging to the Cretaceous and pre-Cretaceous periods (less probably the Jurassic? but certainly one or more period of the Palaeozoic). This succession has a maximum presumed thickness of about 1000 m. below El Kharga district and rests directly on the pre-Cambrian? « Basement Rocks», (in Beris Well N° 2 occurring in the southern portion of El Kharga Oasis, the subsurface section has only a thickness of 600 m.) (Fig. 5).

Concerning the geologic structure, this part of Egypt constitutes a portion of the regional « stable area» occurring on the northern foreland side of the Arabo-Nubian Mass (Picard, 1938, Weeks, 1952). In 1953, the present writer drew the attention to the fact that the desert west

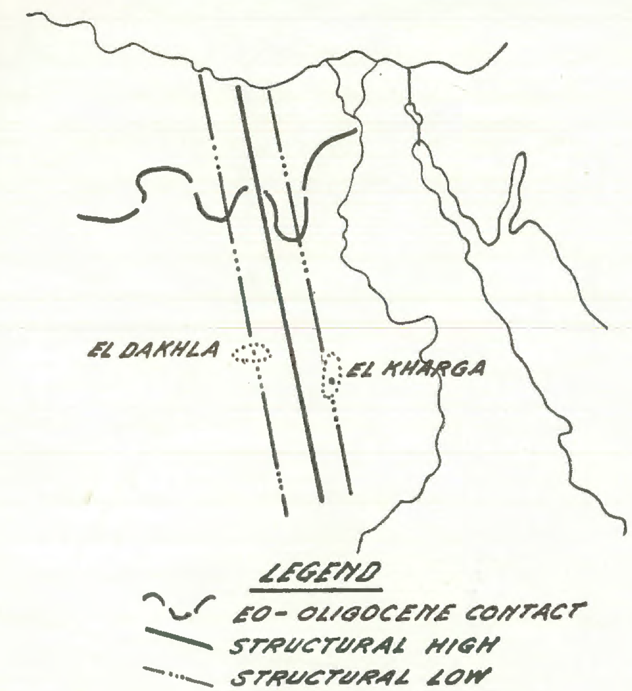

Fig. 5. Map to show regional structural axes affecting El Kharga and El Dakhla.

of the Nile Valley is affected by a number of regional «structural highs» which are oriented in a NNW-SSE direction and which alternate with a number of regional « structural lows». Some of these features extend southward for many hundreds of miles where their iufluence is felt in El Kharga and El Dakhla which represent two structurally low areas occurring on the flanks (one on each side) of a major « high» (Fig. 6). The structure of these two oases, particularily that of El Kharga, is further complicated by young folding and faulting.

The strata of hydrologic interest in El Kharga and El Dakhla areas are composed of Nubian type sandstone and conglomerates, which range from the Palaeozoic (not differentiated) to the Lower Senonian. Very little or almost no work has been published on the stratigraphy, palaeontology and petrology of these strata (Little and Atlia, 1942,

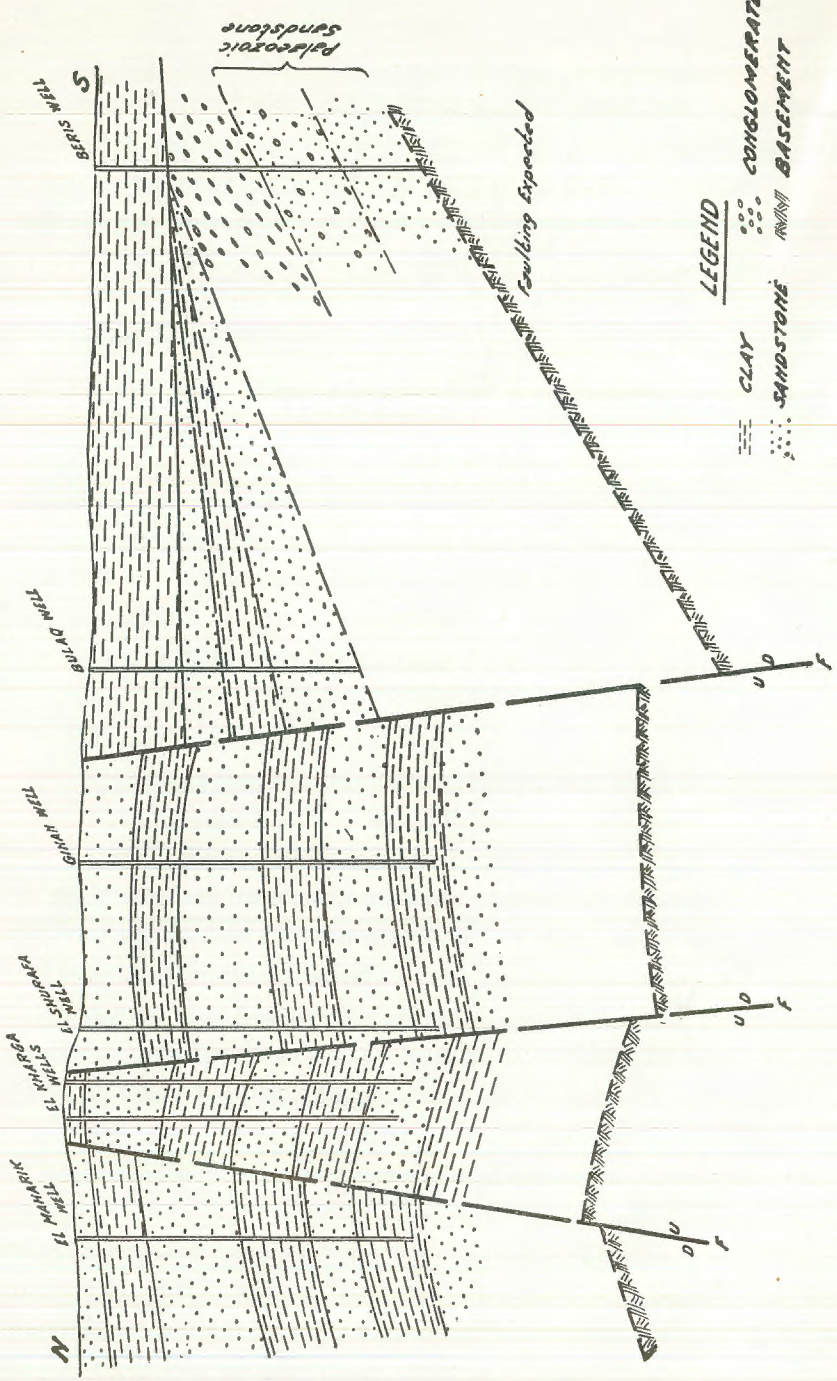

Fig. 6. Geological section through El Kharga Wells.

Paver and Pretorius, 1954). Also the geologic structure (both regional and local) has received little attention from the previous workers.

In El Kharga and El Dakhla, twenty deep wells (average depth 650 m. in El Kharga and 300 m. in El Dakhla) were recently dug with the object of securing the necessary water needed for the agricultural developments. The rock samples obtained from these wells were submitted to the Geology Section of the Desert Institute. Examination of the lithology micropalaeontology and minerology, and determination of the physical properities (porosity, permeability and specific gravity) was made. On basis of the data obtained from this study, regional and local correlations were made. In El Kharga area, our work has approached its end whereas the work of El Dakhla is still in a stage of prematurity. In El Kharga we are fairly well informed about the subsurface geologic succession which is divisible into at least 11 lithologic units composed of alternating sandstones, conglomerates and clays of shallow water nearshore origin. The oldest members of this succession are composed of conglomeratic sandstones (150 m. thick) which rest directly on the basement rocks (these are only reported in Beris Wells N^os^ 1 and 2 Fig. 6).

In Beris Wells N° 2, the huge water production (13,000 m^3/day) is obtained from the conglomeratic sandstone zone lying immediately above the basement rocks. On the other hand, the production of the other wells is obtained from other horizons (these are now classified in detail by Mr. M. El Shazli in his thesis on the subsurface geology of El Kharga Oasis) which are much higher in the chronological succession. About the shape of the basement surface, there is little information about its detailed configuration (the picture given in Fig. 6 is tentative). Further deep boring together with a reconnaissance magnetic study will add much to our knowledge about the basement structure. This structure has certainly a strong bearing on the construction of the reservoir and also on the movement of the inflow (water is said to be confined to certain channels the shape of which is determined by the basement structure).

The source of water in El Kharga and El Dakhla is a diversified problem. However, on a regional structural basis, the conception that water «is derived from the sudd marsh region of the White Nile in the Sudan» may be a sound one. Another conception, which may also

merit consideration is based on the relationship between the regional NNW-SSE structural highs and lows passing through El Kharga and El Dakhla areas and which affect the Nile in the area of the cataracts 2, 3 and 4 lying to the south of Wadi Halfa. We except these structural features to cause a sort of deformation in the wide area between these two oases and the Nile and according by some of the Nile Water is apt to escape into the Nubian type strata. We expect also that this water will be moving in a NNW direction and contribute to the supply of these two oases.

IV. WADI EL ARISH BASIN

This basin occupies almost one third of the Sinai total area. An integrated survey of the northern sector of this basin was made by the Desert Institute on behalf of the Supreme Council of Science. A discussion of the detailed geological and morphological factors influencing the ground water potentialities of this sector was given in a separate paper (Shata, 1959).

The main points of interest are given in the following condensed summary :

1) This basin, crosses the North Sinai foreshore area in a NW-SE direction and represents a shallow consequent valley which though is connected to some lateral subsequents it is described as lacking any real tributaries.

2) In the foreshore area of Sinai there is a strong harmony between the regional geological structure and the occurring land farms. This part of Sinai represents an extensive structural depression lying on the northern flanks of El Halal-El Maghara upward. This depression extends eastward to include almost entirely Ghaza Strip of Palestine. On the south and east, this repression is bounded by the Sinai and Palestine upland masses.

3) In this depression were accumulated, since late Pliocene times, great quantities of alluvial and diluvial deposits brought into it by the wadis having their intake from the upland masses. These deposits were covered in later periods by drift sand formations.

4) In the coastal portion the alluvial deposits are underlain by a calcareous sandstone formation which is comparable to the Kurkar Series of Palestine (Lower Pleistocene, Picard 1943). These are underlain by a Pliocene Beach Conglomerate (Known on the surface at Awlad Ali and dipping gently northward at the rate of 4 m./km.). Following underneath the conglomerates we have a saliferous marl section—Saquia Beds (the microfaunal association of samples collected from these beds as described by Mr. Ghorab of the National Petroleum Association indicates a Miocene age assignment).

5) In this area, the calcareous sandstone formations together with some of the Wadi El Arish gravel series (particularily developed below the present day channel are considered as the main acquifer. The Miocene Marls form the basal beds of this acquifer.

6) It has been pointed out that the main water supply of El Arish Reservoir is obtained from local rainfall on the Risan Aneiza upland mass. Additional supply is presumably obtainable from Wadi El Maazar joining Wadi El Arish from the eastern side. As far as the role of Wadi El Arish master stream and its lateral subsequents (Hareidin, El Greie and El Hassana?) information is needed to evaluate their importance as contributers to the water supply of this reservoir.

7) The geological problems related to that part of the Sinai Peninsula are primarily connected to the stratigraphy of the Post-Pliocene section. From the latitude of El Magdaba-northward to the Mediterranean, test boring is wanted to reveal the real thicknesses of this succession and also to permit examination of the lithology and rock texture of the occurring units.

8) Besides the regional stratigraphy several local problems must be solved of which we shall mention only two :

1. The nature and potentialities of the Cretaceous succession (Cenomanian and Lower Cretaceous Nubian type sandstones) in the Lihfin area. Deep boring is recommended to a depth of more or less 200 ms.

2. The detailed geologic structure of the ground water basin below El Arish town. Solution of this problem can be achieved by systematic

boring, detailed study of the rock samples and eventually making careful correlations. This will help knowing the relationship between the involved three reservoirs described by Paver and Jordan (1956) and in making plans for most useful development.

V. GHAZA AREA

Ghaza area bears strong geological and morphological similarities to the foreshore plain of North Sinai even though it is much narrower.

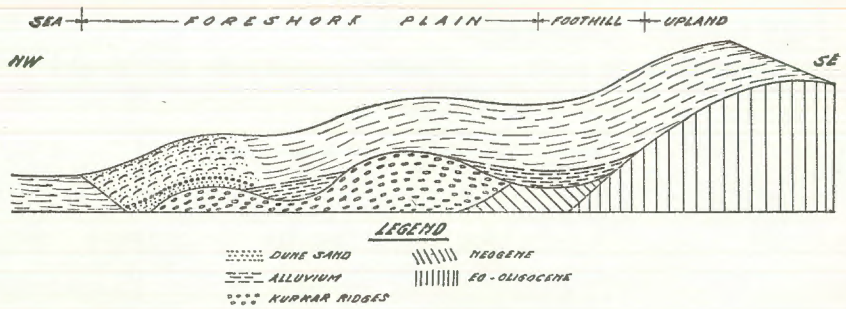

Fig. 7. Blockdiagram section across Ghaza Area.

Ghaza Strip, occupying only a limited portion of this area, has some salient features which are not known in the Sinai area. Most conspicuous among these is the presence of a series of elongate ridges, arranged «en échelon» and running in a N.NE-S.SW direction i.e. parallel to the present Mediterranean coast. The ridges are composed of calcareous sandstones, containing some broken shell fragments (Kurkar series). These alternate with shallow depressions filled with a variety of soil formations ranging from reddish clays to yellow loess. Along the coastal region a belt of modern drift sand is present and extends to beyond Ghaza town in the north. This drift sand has maximum width in the Rafa area (± 7 km.). The calcareous sandstones are porous and are considered as the main acquifer in this strip. These are underlain by impervious Neogene clays. Actual depth to these clays is unknown to us.

In Ghaza area, which is dominated by Wadi Ghaza Basin, there is a regional northwest slope starting from the Palestine Upland Mass to the Mediterranean coast. We expect, therefore, that the rain water

falling annually on the upland mass and on the area in general to follow this slope where it become partly contained in the porous sandstones (Kurkar Series) overlying the Neogene clays.

Late in 1958, the present writer made a reconnaissance geological survey of the Ghaza strip with the object of collecting information required by the hydrologists to make the necessary interpretations regarding the ground water possibilities. Mapping on a scale of 1:25.000 was conducted and several samples were collected for textural, mineral and faunal examination. We are now fairly well informed about the surface conditions. As there is no harmony between these conditions and the subsurface, deep boring is wanted and careful correlations must be undertaken. Untill this work is done the capacity of the water bearing formations cannot be fully established.

In connection with Ghaza Strip we might as well refer to the new wells now drilled at Rafa (Egyptian side) which have an average depth of 80 m. Studies on the samples obtained from these wells are now undertaken. Preliminary results arrived at, indicate that the succession is comparable to that of Ghaza strip. The Kurkar series were reported at a shallow depth from the surface (± 8 m.), act as the main acquifer and continue almost uniformly to the base of the well where a conspicuous gravel band is reported. Tentative correlations made on this band show a westward component dip. Down to that depth the succession belongs to the Quaternary period. Attempts to correlate this succession with those reported in Wells both in Ghaza area and in North Sinai will be made.

REFERENCES

1. Ball, J. (1900). *Kharga Oasis, its Topography and Geology*. Mem. Survey Dept., Cairo.
2. Beadnell, H. J. L. (1909). *An Egyptian Oasis,* London (1905).
3. Dixey, F. (1950). *A Practical Handbook of Water Supply,* Thomas Murby and Co., London.
4. El Samny, A. (1958). Reclamation Project of the area close to the Cairo-Alex. Road (in Arabic), *Engineer's Magazine,* No. 9, Cairo, Egypt-UAR.
5. Fox, C. S. (1959). The Geology of Water Supply, *The Technical Press, Ltd.,* London.

6. Paver, G. L. and Pretorius, D. A. (1954). Report on Hydrological Investigations, Kharga and Dakhla Oases.
Pub. Desert Institute No. 4, Cairo.

7. —— (1954). Report on Reconnaissance Hydrological investigation in the Western Desert Coastal Zone. *Pub. Desert Institute,* No. 5, Cairo.

8. Paver, G. L. and Jordan, J. N. (1956). Report on Reconnaissance Hydrological and Geophysical Observations in North Sinai Coastal Area of Egypt. *Pub. Desert Institute,* No. 7, Cairo.

9. Shata, A. (1957). Remarks on the Physiography of El-Ameriya-Mariyut Area. *Bull. Soc. de Géog. d'Egypte,* T. XXX, Cairo.

10. —— (1959). Ground Water and Geomorphogeny of Wadi El Arish Basin. Part I. *Bull. Soc. de Géogr. d'Egypte,* T. XXXII, Cairo.

ON THE MORPHOLOGY OF THE EASTERN MARGIN OF THE CENTRAL NORTH ETHIOPIAN PLATEAU

BY

Y. ABUL-HAGGAG

The eastern belt of the interior plateau in central North Ethiopia is of a particular importance in the geography of the whole Ethiopian domain [1]. Lying between the Great Escarpment which overlooks the eastern slopes on the one hand and the heart of the interior plateau on the other, it extends in a generally north-south trend from the Asmara zone to the northern boundaries of Abyssinia, except for the tract extending between the Decameré and Saganeiti zones which assumes an east-west direction (Fig. 1). This general meridional trend is continued in Abyssinia to the Hawash depression.

On account of this general disposition, of its commanding position and its mild climate throughout the year, this belt has always played an important role in the human geography of Ethiopia. Although on the whole a rugged country it affords the least difficult junction between the Eritrean and the Abyssinian plateaus, as well as the most direct passageway from the interior to the only natural harbour in the territory, namely Massaua. It has been the route of all civilisation currents penetrating into the heart of Ethiopia from the north, while its importance as a

(1) In this article the term 'Ethiopia' refers to the political unit known by this name, including Eritrea (North Ethiopia) which is now an autonomous unit under the Ethiopian Crown. The term 'Abyssinia' refers only to the remaining part of the Ethiopian State. In the interior plateau the boundaries between Eritrea (N. Ethiopia) and Abyssinia coincide with the upper and middle reaches of the Mareb river.

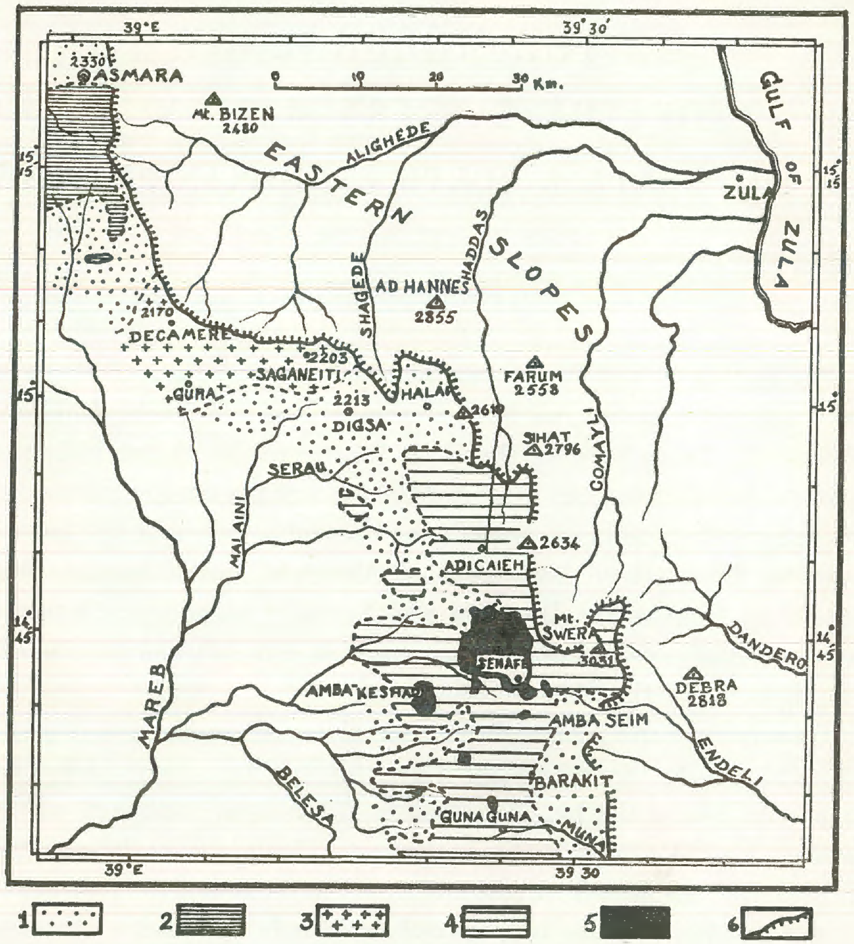

FIG. 1. Landforms in the eastern belt of the interior plateau of Central Eritrea (N. Ethiopia).

1. Varied Landforms of the Archaean metamorphic formations, including the Asmara fossil peneplain. Profound dissection and gentle hill sides where soft argillaceous schists predominate. 2) Tabular and conical hills in basalt terrain. Open, shallow valleys in the north. 3) Joint-controlled hill-forms (cuboidal masses and whale-backs) in granitic terrain. 4) Tablelands and «ambas» of Adigrat sandstone. Canyons in places. 5) Trachytic crags. 6) Great Escarpment.

trade and military route can hardly be exaggerated. It was the most trodden track of the Axumite traders, while the inhabitants of Adulis found a pleasant summer resort in its cool and enervating altitudes. In 1867-68 it was followed by the English expedition in its drive towards the south, and it was equally favoured by the Italian forces both in 1885 and 1935. Nowadays it is followed by 170 kilometres of the magnificent, all-weather road which connects Asmara with Addis Abeba.

From a morphological point of view the belt is unique in that it possesses an amazing variety of landforms hardly to be expected in any other part of equal area in the Ethiopian lands. In a trip from Asmara to Barakit the traveller can observe almost all the landform types represented in the Ethiopian plateau, while he will have abundant food for thought concerning the general problems of denudational chronology in this part of Africa. The diversity of morphological landscapes in the belt is due mainly to its geological constitution. Almost all the geological formations of the North Ethiopian interior plateau are here represented. The Archaean crystalline basement is to be seen nearly everywhere, whether as extensive tracts or in valley-sides amidst other formations. Like analogous formations in the eastern and north-eastern parts of Africa and in the Arabian peninsula this series consists of an extraordinary variety of rocks of diverse origin and lithology, including different metamorphic formations, granites, diorites, crystalline limestones and dyke-rocks. The 'plateau rouge', a lateritic, usually red, mantle which overlies this ancient basement in southern Eritrea and Tigré is best developed in the surroundings of Asmara. The Mesozoic Adigrat sandstone covers an extensive part south of the Halai parallel; while both the basalt and the trachyte of the 'Trappean Series' of Blanford are also represented.

This article, based partly on my field observations, is essentially an attempt to describe, on a genetic basis, the diverse landforms in the area, including a discussion of the reasons for its altimetric supremacy, the origin of the Great Escarpment, the interpretation of the characteristically senile landscape of the Asmara zone and the origin of the Senafé trachytic hills. The general question of the cyclic evolution of the Ethiopian lands is also touched upon.

THE GREAT ESCARPMENT

The divide between the Mareb (Gash) and the torrents flowing towards the Red Sea often follows the sinuous crest-line of the great, generally sea-ward facing, escarpment which sharply defines the eastern limit of our belt. In this part of Ethiopia the escarpment face is invariably steep. It is steep enough even in the granitic terrain of the central tract. Further south where the predominant formation (sandstone) is naturally suited to the formation of escarpments the vertical distance between the crest-line and the valleys at the base can attain a thousand metres. In the north an idea of the feature may be gained from the fact that the road and railway between Ghinda and the escarpment's crest near Asmara —a direct distance of only 20 kilometres—make a laborious ascent of about 1500 metres. Here then is a veritable escarpment face, precipitous and imposing to the extreme (*Plates I and II*).

This great steepness, together with the fact that the Great Escarpment assumes a general meridional trend all the way from the northern frontiers of Eritrea to the Hawash depression, led to the supposition that the escarpment crest as we see it to-day nearly coincides with the major fault-line below which the graben zone was downthrown.

Morphological evidence tells, however, against a tectonic origin. To begin with, effects of erosional activity are everywhere abundantly clear. The short powerful torrents plunging from the interior to the coastal lowlands are naturally possessed of a great destructive force and must be forcing the escarpment back almost everywhere. Actively engaged in extending themselves by retrogressive erosion, they have developed numerous breaches and embayments in the escarpment which has thus become scalloped in many places. In some localities they have even pushed their source reaches some distance into our belt, beyond the divide line. An example of this is to be seen in the Asmara zone where the upper Aidesero (Alighedé) has succeeded in isolating segments of the plateau (as, e.g.., Mt. Codemas), with one of its source affluents pushing its head to less than 100 metres from the plateau-summit main road. The Endeli torrent in the Senafé zone is also a good example of the process.

It is also noteworthy that outward from the high escarpment crest large segments of country attain comparable—in places even greater—height Thus Mt. Adi Hannes (north east of Saganeiti) attains an elevation of 2855 metres above sea-level and Mt. Sihat (north east of Adi Caieh) rises to 2796 metres, the elevation in both cases being greater than in the neighbouring interior. Further south, Amba Debra is 2818 metres high, that is, it exceeds the average altitude of the Swera plateau.

There thus seems to be little doubt that the Great Escarpment is a purely erosional feature. It is the outcome of steady scarp retreat which is extending the eastern slopes at the expense of the interior plateau.

It is possible, however, that *locally* the escarpment is of a tectonic origin. In one of its salients, in the Ad Nefas zone north of Asmara, the front overlooking the Macallo valley is cut by short ravines into a series of faceted spurs, the triangular facets of which are fairly systematic in form and position, with their bases aligned along the front (*Plate I*). The Macallo valley itself is strikingly straight and may have well been excavated along a fault-line. This part of the Great Escarpment may therefore be considered a fault scarp determined by a relatively recent displacement. This interpretation is, however, of a tentative nature since the writer did not have the chance of a more careful examination of the other side of the Macallo valley.

AN UPWARPED COUNTRY

The reason for the superior elevation of the belt as a whole may now be considered. It is a remarkable fact that this area is generally higher than the rest of the interior plateau of central Eritrea, while the surface exceeding 2500 metres in elevation is more extensive here than in any other part of North Ethiopia. In a clear day the main basalt plateau in the west, the Red Sea, and localities as distant as the Adwa and the Semien mountains in Abyssinia can be distinctly seen from many a commanding point in this marginal land. The highest point in the whole Eritrea is found here.

In all probability this altimetric supremacy is due to a more intense upwarping witnessed by this belt during the uplifting movements which

involved the Ethiopian lands during the Tertiary, *before* the great dislocations which brought about the Red Sea basin. The average inclination of the crystalline basement surface as resulted from this upheaval is quite insignificant in most parts of the plateau, being generally less than 1 %, while in this marginal belt it is usually 2.2-2.5 % (i.e. 22-25 metres in the kilometre). In the Senafé zone the inclination of this surface can exceed 6.5 % (i.e. 65 metres in the kilometre) [1].

This more intense upraising of the basement surface extends, in fact, to the country lying off the crest of the Great Escarpment where this ancient surface can locally attain a greater elevation than in that crest. This is the case, for instance, in Amba Debra where the basement surface (which is here overlain by the Adigrat sandstone) is higher than in the Swera plateau. In other words, the maximum elevation occurred along a line lying somewhat outside the present Great Escarpment.

The greater elevation of the eastern peripheral belt, relatively to the rest of the interior plateau of Central Eritrea, is thus to be regarded as an outcome of one of the local deformations which accompanied the otherwise uniform uplift of Eocene times. The feature should not be attributed to the later (Miocene) rifting which produced the Eritrean Trench. It is noteworthy that the same remark has been made about the rifted zones of Lake Rudolf and northern Nyassaland where the higher segments along the edge of the Rift Valley are attributed to the pre-Miocene uplift [2].

The origin of the higher altitude of our belt thus conceived, it is to be concluded that dissection of its surface must have begun a long time ago both by the streams that flowed across what became later the eastern slopes of the plateau and those which flow towards the Mareb river, the upper basin of which is itself a gently downwarped country attributable to the inequalities of the same uplifting movements of the Tertiary. To this is due, in part, the generally rugged nature of the belt. Although

[1] G. Dainelli, *Geologia dell'Africa Orientale,* Rome, 1943, Vol. III, pp. 251-252.

[2] See F. Dixey, *Some Observations on the Physiographical Development of Central and Southern Africa,* Trans. of the Geol. Soc. of South Africa, Vol. XLI (1938), pp. 113-171.

its western part is less rugged than in the east it remains a badly broken plateau and erosion by the affluents of the Mareb, assisted from the beginning by the upwarping movement, exhibits much of the juvenile aspects of the eastward drainage (*Plate IV*).

LANDFORMS IN THE METAMORPHIC TERRAINS

Turning now to a survey of the landforms in the area, it may be noted that the determining factor in their amazing diversity is in the first place the lithologic constitution of its various formations. Landforms due to faulting are practically negligible, only local and doubtful examples being present. The marginal upwarping has not been of equal intensity, the western flank of the arch being, for instance, much less inclined in the Asmara zone than in the Halai and Senafé zones. This may perhaps be a contributing factor in the minor degree of dissection suffered by the Asmara zone in comparison with the two latter zones. But, on the whole, tectonic movements may be dismissed as factors of secondary importance in diversifying the landscape.

Nor is the climatic factor of any great significance in explaining the diversity, the prevailing climatic conditions being more or less similar throughout the belt. Rainfall occurs mainly in summer (especially in July and August) and is usually of the convective type consisting almost solely of afternoon thunderstorms and showers. The annual total is remarkably uniform, being 500 mm. in Asmara in the north, 518 mm. in Halai in the centre and 460 mm. in Senafé in the south. Temperature is everywhere mild throughout the year (perennial spring climate), the mean annual temperature in Asmara being 17.9° C. with an annual range of only 3° C. The diurnal range is much higher than the annual range but nowhere do the cold and heat attain an excessive degree during any long period of the year.

A classification of the landforms in the area thus turns to be based in essence on the varying geological constitution. Beginning with the metamorphic formations of the basement complex it will be noted from the map (Fig. 1) that they predominate in the northern part of the Asmara zone and in much wider areas further south. Owing to the great diversity

of these formations and to certain important differences in the later phases of geological history in the various localities where the basement is exposed, a striking variety of landforms is to be expected.

The Asmara plateau assumes an interesting and rather problematic aspect. Seen from the air or from the crest of the Great Escarpment overlooking it from the east, it appears almost perfectly plane. Travelling from the capital towards the north or west one is readily struck by the subdued nature of the landscape, the roads running in straight lines across an undulating country covered for the most part by a thick layer of detrital material. Only occasionally is the monotony of the scene broken by the rising of hard rock hills which owe their prominence to their isolation rather than to their height above the general surface (*Plate III*). The predominant rocks in this northern part of the Asmara plateau are intensely metamorphosed formations including, in particular, chloritic schists and other green rocks together with mica schists and gneisses. The small hills are mainly outliers of the lateritic cover, and are either conical (as, e.g., the Cuddo-Cuddo hill, south-east of the town) or of the flat-topped and steep-sided type (as, e.g. Amba Galliano, which overlooks the capital from the north-east).

South of Asmara the crystalline basement is buried under a thin sheet of basalt. The relief, however, remains faint and the surface maintains its undulating character. Everywhere in the Asmara plateau the stream valleys are open and shallow and, in the dry season, some of them become almost imperceptible.

Here then is a characteristically senile landscape which, for reasons to be dealt with later, contrasts strongly with the landscape in most other parts of the belt where the metamorphic formations are exposed. In these parts the metamorphics are predominantly argillaceous-phyllitic schists much less intensely metamorphosed than in the Asmara zone. A notable characteristic of these schists is their relatively low resistance to erosion. Hence the usually profound dissection of the land-surface in this terrain, so that despite the general plateau character demonstrated by the absence of any conspicuous peaks towering over the general level the relief is extremely varied and in places, especially in eastern localities as, e.g., the Halai zone, assumes an Alpine aspect. Valleys are usually deeply incised and where the schists are very soft their floors are unproportionately wide, with innumerable earthy mounds giving the whole scenery a chaotic and wild appearance. An outstanding example that can be seen from the main road between Saganeiti and Adi-Caieh is the valley of Mai Serau in the Mareb basin (*Plate IV*). Hills usually assume rounded and smooth outlines, and on their summits and flanks weathering has often produced a thick mantle, the bare rock being only rarely exposed. Such hills thus acquire a dull, and rather unpleasant appearance which is in sharp contrast to forms of granitic terrain.

LANDFORMS IN THE GRANITIC TERRAIN

Granites of the basement complex predominate in the Decameré and Saganeiti zones, other rocks like diorites and metamorphics autcropping in relatively limited tracts. Granitic rocks, however, are far from being homogeneous in their resistance to the denuding agencies, while both vertical and cross joints are well-developed. The hills are therefore distinct by their sharp outlines and curiously eroded forms. In many instances the rock blocks are piled one above the other in strikingly delicate positions (*Plate V*). Through their long branching roots, the famous Ethiopian euphorbias (which are particularly abundant in this part of the belt) have greatly assisted in the dislocation of huge masses of granite that are often seen scattered at the feet and lower slopes of the hills. Where curved jointing is developed, smooth whale-back surfaces and rounded hills are present. The cracking of the rock is frequent in the rounded granite blocks, the grooves giving them a characteristic appearance.

Near Decameré flat-summited granitic hills, or table mountains, are also to be seen. Such a form is, however, rare (here possibly due to a particularly resistant horizon at the summit), the general rule being the irregular and bizarre outlines which give this granitic country its distinctive morphological character.

LANDFORMS IN THE SANDSTONE TERRAIN

The southern part of the belt is fundamentally an extensive dissected tableland made up of the Adigrat sandstone. This formation was deposited in the littoral belt of the Mesozoic sea which advanced over the Palaeozoic surface from the south-west to the north-east. In the absence of any subsequent foldings of any great significance, the upwarping of the belt being broad, the sandstone layers remained almost everywhere sub-horizontal. To this and to the fact that the Adigrat sandstone represents a resistant quartzitic formation, is due the distinct mode in which the surface has been sculptured by erosion. Tabular surfaces in the form of extensive plateaus or 'ambas' (i.e. mesas in geomorphological nomenclature) constitute the most persistent feature in the landscape. The scarps bounding the hills and flanking deeply incised valleys are invariably steep (*Plate II*). Where the formation is massive—which is often the case—they are clear-cut, unscalable walls, in which jointing is in places admirably exhibited. Where bedding is pronounced and there is an alternation of resistant and less resistant layers, step-like benches are more the feature. Caverns, determined by the variable resistance of the cementing material, are often seen in valley sides as, e.g., in the northern wall-like side of the Guna Guna valley.

One of the most typical sandstone tablelands is the Cohaito plateau which rises to an average elevation of 2600 metres east of the Adi Caieh zone. Its summit-surface, 15 kilometres long by 2.5 kilometres wide, is remarkably flat. In the east it overlooks the Comayli valley, more than 1000 metres below, with an imposing precipitous scarp (*Plate II*). Its western flank, overlooking the Haddas valley, is also very steep, and has been regarded by some as a fault-scarp. Equally steep-sided and flat-topped is the Swera plateau (Fig. 2) which has an average altitude of 2600-2700 metres, with its highest part in the north-east where Mt. Emba (or Swera) attains the greatest elevation (3013 metres) in North Ethiopia. The eastern flank of this plateau has also been regarded as a fault-scarp. In the light of our discussion of the origin of the Great Escarpment this opinion must be discarded. This

flank is the outcome of erosion carried out particularly by the Endeli and Dandero torrents which cascade to the Dancalian depression. The active headward erosion of these torrents has led to the fact that the water-divide between them and the Mareb basin no more corresponds to the Swera plateau but has been pushed several kilometres to the west, i.e. to the Senafé zone (Fig. 2).

The Barakit plateau, south of the Senafé zone and the country lying further south exhibit the same general features of sandstone landscape.

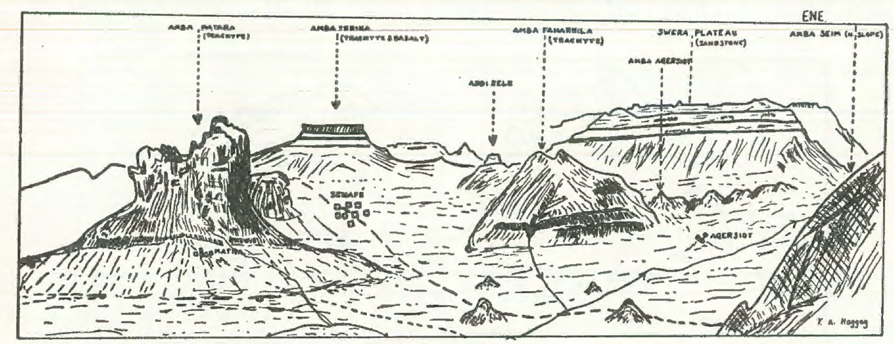

Fig. 2. Sketch drawn from the northern slopes of Amba Seim, showing typical land forms in sandstone and trachytic terrains. In the Senafé plain runs an affluent of the Endeli torrent which has thus succeeded in pushing its head beyond the crest of the Great Escarpment (post-rifting cycle of erosion).

Dissection of the land-surface by the Belesa (Mareb) and the Muna (Endeli) torrents is, however, more advanced and the 'ambas' play, therefore, a more pronounced role in the landscape. Where the more readily eroded schists are exposed below the sandstone scarps, contrastingly gentler slopes develop, though these slopes are always somewhat steepened by talus derived from the steep sandstone portion above. The characteristic concavity of the profile thus developed in the 'ambas' here is, therefore, the product of lithological diversity, and is evidently independant from the stage of erosion attained by the landscape.

LANDFORMS IN THE LAVA TERRAINS

Of a form and origin entirely different from those of the sandstone 'ambas' are the isolated hills that emerge in and around the Senafé

plain. These geologically and morphologically interesting hills consist mainly of trachyte, a viscous lava which had piled itself in the form of rounded bosses or curiously shaped crags instead of welling out in successive streams one over the other as is the case in the basalt terrain. A typical example is the so-called Amba Senafé in the outskirts of the small town of Senafé. A massive, bell-shaped block of one solid mass of reddish brown trachyte, bare and smooth, its face dotted with huge hollows and traversed by long ferruginous streaks, it is both imposing and unmistakable (Fig. 3). Equally conspicuous, but more craggy,

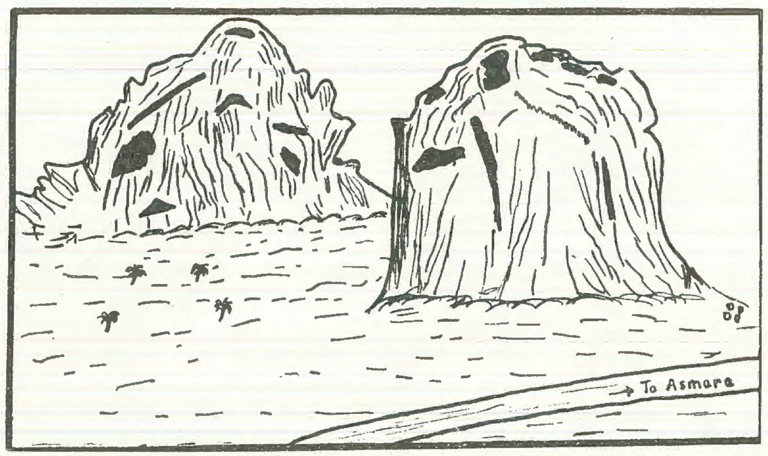

Fig. 3. Trachytic hills of the Senafé zone. View from outskirts of Senafé, looking west.

is the neighbouring Amba Matara which rises some 300 metres above the level of the Senafé plain (Fig. 2). Amba Seim, rising even more highly above the plain, exhibits, so to speak, a great measure of 'structural determinism' in its morphological form. The summit consists of a compact and resistant trachyte, is very steep, and in parts quite craggy. Next follows the Adigrat sandstone, constituting a belt some 50 metres in thickness, with its surface weathering into red soil. This formation is also resistant but less so than the capping rock, the mountain thus becoming less steep. A much gentler slope coincides with the underlying metamorphic horizon, a gray and greenish schist in which foliation is almost vertical. This constitutes the broad base of the mountain and is

littered with fragments from the overlying terrains (*Plate VI*). In the two latter horizons vegetation of a bushy type is more dense than in the trachytic cap. At the time when I climbed the mountain (in June, that is before the main rains) this was especially the case at the junction of the sandstone and the schists, evidently because the humidity absorbed by the porous sandstone is maintained by the impermeability of the argillaceous schists.

The same stratigraphical sequence and varying slope is encountered in the huge Amba Keshad to the west, in Amba Messahal to the south and in other minor hills in the area. Of a different form is the Amba Terika which lies due north of Senafé and is a most conspicuous object from the surrounding country (Fig. 2) Its broad base consists of metamorphic rocks and is, as usual, of a relatively gentle slope. But in the steep uppermost portion, more than 600 metres in thickness, basalt occurs alternately with the trachyte in distinct stratification. The summit is of the flat type, resembling in this respect the 'amba' summits in basalt terrain.

The origin of these isolated inselberg-like hills is not quite clear. Blanford [1] saw in them the remnants of a formerly continuous great lava flow. This view evidently implies an advanced stage of post-trappean erosin of which there is, however, no evidence in the rest of the region.

It seems more probable that these hills indicate local intrusions, i.e. accumulations of lava upon individual foci of flow which were localised in this zone (as well as in the identical Adwa zone in Tigré) on account of some particular weakness in the crust. The disturbed nature of the area is, moreover, testified by the presence of a number of lava dykes. These find topographical expression in outstanding rises such as the low hills extending across the plain north of Amba Seim (Fig. 2).

Contrasting strongly with these trachytic crags are the tabular and conical hill-forms carved out in the basalt terrain south of the Asmara zone. The horizontality of the basalt sheets is nearly perfect, while they are often intercalated with layers of volcanic ashes and sedimentary

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[1] W. T. Blanford, *Observations on the Geology and Zoology of Abyssinia*, London, 1870, p. 42.

formations indicative of wind or water-borne deposition during calm intervals. Hence the flat-summited 'ambas' which are bound by steep, benched sides. As the scarps of the 'amba' continue to retreat under weathering, gravity downhill movement of the debris, etc. their benched profile is gradually smoothed out and the 'amba' may pass into a symmetrical cone. Such conical hills are not, however, so common as the flat-topped mesas, a possible proof of the attenuated degree of dissection suffered by this part of the belt.

CYCLIC EVOLUTION

The current cycle of erosion operating in most parts of the belt and in most other parts of the North Ethiopian interior plateau was probably inaugurated by the Tertiary (possibly Late Eocene) regional uplift. In lava Terrains the cycle dates of course from the cessation of volcanic activity, possibly in the late Miocene or the early Pliocene. The formation of the Eritrean Trench (probably in the lower Miocene) inaugurated the cycle of erosion that is still current in the eastern slopes and the effects of which are represented mainly by the process of scarp-retreat that is gradually reducing the width of our belt.

Prior to the Tertiary the land-surface passed through a complete cycle of erosion only during the Palaeozoic era when the crystalline basement was uninterruptedly exposed to subaerial erosion. At the end of this cycle the surface was reduced to an almost perfect peneplain, comparable with the Pre-Karroo surface of South Africa. With the exception of the Asmara zone this ancient peneplain is not directly represented in the present surface. It probably accounts, however, for the general accordance of summit-level which is recognizable in most areas where the crystalline rocks are exposed.

According to one view the crystalline surface of the Asmara zone represents an intact part of this Palaeozoic peneplain. This view fails, in our opinion, to answer an important morphological question : how could such a surface escape destruction throughout the vast time extending from the beginning of the Mesozoic to the present time, if it has really remained continuously exposed? We, therefore, suggest that we are

dealing, instead, with a fossil peneplain that was resurrected in post-trappean times after the removal of a thin lava cover which had acted as a protective shield. The small thickness of the basalt sheet facilitated the resurrection of this peneplain by the erosive agencies without these being particularly vigorous.

It may also be added that there are no secure morphological grounds for supposing a multiplicity of cyclic surfaces in the Ethiopian lands such as has been claimed by Desio [1] and by Merla and Minucci [2]. The undoubted presence of a widespread surface of planation comparable, for instance, with the well known Miocene peneplain of south Africa has never been really established. It is true that in the southern portion of our belt a summit-level accordance is recognizable across the Adigrat sandstone and the stratigraphically higher trachyte (Fig. 2). It must be remembered, however, that the sandstone segments lie on, or near, the axis of our upwarped belt, while the trachytic hills lie on the western flank of the arch, these conditions thus producing only a false semblance of a hill-top plain. Moreover, the persistent coincidence of the surface and the bedding-plane in both basalt and sandstone terrains and the survival of the lateritic crust where the basement surface is exposed are facts that can hardly be reconciled with the assumption of a plurality of cycles of erosion.

Most of the present landforms can in fact be explained as features developed during the current cycles of erosion which we mentioned at the beginning of this section of the article. This evidently implies a slow tempo of erosion, proofs of which are not, we think, lacking in other parts of the Ethiopian lands.

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(1) A. Desio, *Resti di antiche superfici di degradazione nell'Etiopia centrale,* Riv. Geog. Italiana, Anno XLVII (1940), pp. 3-10.

(2) G. Merla and E. Minucci, *Missione geologica nel Tigrai,* Vol. I, Rome 1938.

Photo 1. The Great Escarpment. View eastward from near Ad Nefas, north of Asmara.

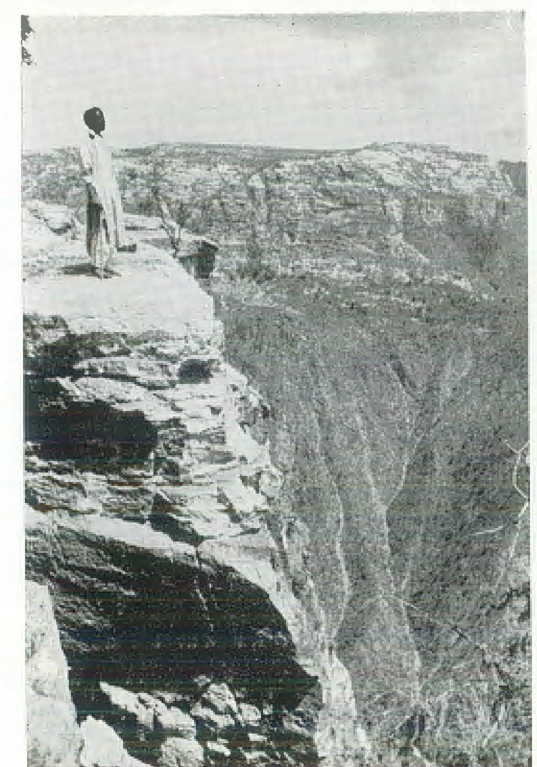

Photo 2. The Upper Comayli canyon (1000 metres deep) excavated in Adigrat Sandstone. View from near the Coloe ruins in the Cohaito tableland.

Photo 3. The Asmara peneplain. The steep-sided and flat-topped hill in the background is a remnant of the lateritic crust overlying the crystalline basement.

Photo 4. View from the road between Saganeiti and Adi Caieh, looking down the Mai Serau valley. Being excavated in weak schists this wide deep valley seems, at first sight, out of proportion to the small stream winding its way in the centre.

Photo 5. A steep hill of granite which has broken into joint-bounded blocks, near Decameré. Note the cracking of many blocks and the characteristic absence of talus at the base.

Photo 6. Amba Seim (trachyte-capped), rising in inselberg fashion above the Senafé plain. View southward.

LES GRANDES RÉGIONS MORPHOLOGIQUES DE CHYPRE

PAR

E. DE VAUMAS

Si l'île de Chypre a été une des premières contrées de la Méditerranée à faire l'objet de recherches géologiques approfondies, il n'en a pas été de même sous l'angle géographique, et notamment du point de vue géomorphologique. Les publications que l'on peut citer dans ce domaine sont très peu nombreuses et très fragmentaires, aucune vue générale ne s'en dégage et rien ne peut y être mis en parallèle avec les mémoires ou les articles de A. Gaudry (1862), F. Unger et T. Kotschy (1865), R. Russel (1882), A. Bergeat (1892), C. V. Bellamy et Jukes-Browne (1905), C. G. Cullis et A. B. Edge (1922), C. Renz (1929), F. R. C. Reed (1929-1930), F. R. S. Henson, R. V. Browne et J. Mc Ginty (1949), ni avec les actuels «*Annual Reports of the Geological Survey*».

Désireux d'aider à combler cette lacune, nous avons donc entrepris durant l'été 1958 une première prospection géomorphologique de l'île de Chypre qui sera complétée, espérons-nous, dans les années suivantes par une étude plus détaillée de cette île qui se révèle déjà si riche d'enseignements.

Avant de procéder ici à une esquisse descriptive des grandes régions morphologiques de Chypre, nous nous faisons un devoir et une joie de dire notre très grande reconnaissance à Monsieur F. T. Ingham, Directeur du Geological Survey of Cyprus, ainsi qu'à ses collaborateurs [1]. Ils nous ont

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[1] L'Editeur du Bulletin de la Société de Géographie d'Egypte remercie le Dr. F. T. Ingham, Directeur du «Geological Survey Department, Nicosia, Cyprus» d'avoir bien voulu l'autoriser à publier cet article qui paraît en version anglaise dans l'ANNUAL REPORT 1958, du Geological Survey de Chypre.

accueilli avec une courtoisie et une amabilité qui nous ont profondément touché, ils n'ont rien épargné pour faciliter nos recherches et ont mis à notre disposition avec une très grande libéralité toute la documentation dont ils disposaient et qui pour la plus grande partie n'est pas publiée. Sans eux, ces pages et les publications qui doivent les suivre auraient été impossibles.

La coutume s'est établie de distinguer dans l'île de Chypre trois régions principales : la chaîne de Kyrénia au Nord, le massif du Troodos au Sud et la plaine de la Mésaorée, située entre les deux. Cette division est valable sous l'angle de la géographie générale. Elle l'est beaucoup moins sous l'angle géomorphologique où il est plus naturel de distinguer seulement : la chaîne de Kyrénia (avec son prolongement la péninsule de Karpas) et ses bordures, — le massif du Troodos et ses bordures ; — la Mésaorée n'étant en réalité que la juxtaposition des piémonts des deux chaînes montagneuses que sépare une ligne jalonnée par les rivières Serakhis, Ovgos et Pedieos.

I. LA CHAÎNE DE KYRÉNIA, LA PÉNINSULE DE KARPAS ET LEURS BORDURES.

Du cap Kormakiti au cap Andréas, la chaîne de Kyrénia et la péninsule de Karpas s'allongent sur 160 km. de longueur. Elles sont formées, surtout la première, d'une ride montagneuse flanquée de deux piémonts.

1. La chaîne de Kyrénia et la péninsule de Karpas.

A. *La chaîne de Kyrénia* est constituée par quatre festons arqués dont la convexité est tournée vers le S.-S.O., le S. et le S.-S.E. et que séparent des seuils assez bas, utilisés par les routes Myrtou-Lapithos, Nicosie-Kyrénia, Lefkoniko-Akanthou. Le feston le plus occidental est court et peu élevé ; il aboutit à la mer entre Orga et un point situé à 3 km. à l'Ouest de ce village ; il semble probable que son interruption brusque qui coïncide avec le littoral est due à une grande faille. Les autres festons (St. Hilarion, Buffavent, Kantara) dépassent ordinairement 2000 pieds et culminent un peu au-dessus de 3000 pieds.

La chaîne de Kyrénia a été interprétée jusqu'ici comme un anticlinal déversé et poussé vers le Sud, des plans de charriage y ont été reconnus. Cette vue des choses, en l'absence de levés géologiques détaillés, n'est encore que globale mais ne paraît pas devoir être remise en question pour l'essentiel. On peut remarquer seulement que le feston de Kantara paraît plus régulier que les autres et qu'il s'agit peut-être dans son cas d'un anticlinal droit (ou légèrement déjeté qui marquerait une transition entre l'Ouest de la chaîne plus violemment affecté par les efforts orogéniques et la péninsule de Karpas dont la structure est beaucoup plus calme.

Quoi qu'il en soit, le relief est relativement simple. Vus du Nord ou du Sud, la chaîne se présente comme une muraille dont les matériaux sont presqu'exclusivement calcaire (*Hilarion Formation*) ; les flancs sont très abrupts tandis que le sommet est quelquefois occupé par des replats. Ces caractéristiques correspondent bien à la structure d'un pli déversé dont le noyau dur a percé les couches plus tendres qui le recouvraient primitivement.

Malgré sa nature calcaire, la chaîne ne révèle que très peu de formes karstiques. Cela se comprend aisément. L'étroitesse de la montagne (2 km. au maximum) et la raideur des versants ont favorisé le ruissellement aux dépens de l'infiltration, et cela d'autant plus que les précipitations à Chypre ont tendance à se faire de manière brusque et massive. Une certaine partie des eaux atmosphériques s'infiltrent cependant comme en témoignent le petit poljé, situé près du château d'Hilarion, et les sources vauclusiennes qui jaillissent au pied de la montagne et dont les plus célèbres sont celles de Kythrea et de Lapithos.

B. *La péninsule de Karpas* lance dans la mer une avancée qui semble interminable (il y a 80 km. en ligne droite de Trikomo au cap Andreas !) Le feston de Kantara vient s'y terminer mais l'axe anticlinal de celui-ci s'y continue dans le flysch jusqu'à l'extrême pointe de la péninsule comme en témoignent les dépôts pliocènes qui la ceinturent et qui sont inclinés de chaque côté en direction de la mer. L'altitude est faible

(1194 pieds au maximum au Pamboulos) et ne fait que décroître, d'Ouest en Est, cette constatation suggère un ennoiement progressif en contraste avec ce qui se passe à l'autre extrémité de la chaîne où la terminaison est beaucoup plus brusque.

Le relief est original. L'érosion y a profondément éventré le flysch qui donne de grandes cuestas en plusieurs endroits. Un de ces crêts entourent le point où disparaît le feston de Kantara (dépression de Platanisso), un autre dessine deux grandes combes sur le bord S.-S.E. de la péninsule. A ces reliefs s'en ajoutent d'autres moins importants et qui sont engendrés par la dissection de la couverture pliocène. Selon le pendage de celle-ci, on a des plateaux se terminant en corniche (région de Galatia) ou des crêts (région de Galinoporni).

2. Le piémont septentrional.

Ce piémont est étroit (2 à 5 km. de large). Il borde la chaîne sur toute sa longueur. Deux groupes de relief y apparaîssent : des terrasses marines et le piémont proprement dit.

A. *Les terrasses marines* se suivent tout le long de la côte entre le niveau de la mer et la courbe de 300 pieds. Les terrasses sont parfois très bien conservées sur le bord même de la mer, elles le sont beaucoup moins bien quand on progresse vers l'intérieur par suite des apports considérables de matériaux détritiques amenés par le ruissellement, les glissements ou le creeping. D'une manière générale, les falaises, témoins des anciens niveaux de la mer, sont très dégradées et ne se suivent sur le terrain que sur des longueurs assez faibles. La cause en est imputable au caractère peu résistant des roches dans lesquelles elles ont été sculptées et à la violence du ruissellement sur la face Nord de la chaîne de Kyrénia.

B. *Le piémont proprement dit* monte de 300 à 1000/1200 pieds d'altitude et correspond presque partout aux affleurements du flysch. Celui-ci a un pendage vers le Nord de 30 à 40° en moyenne.

A l'Ouest de Kyrénia, il est découpé en crêtes qui attirent déjà l'attention par la subhorizontalité de leur sommet qui tranche les couches du flysch. A l'Est de Kyrénia, dans la région de Klépini-Trapeza, le flysch moins disséqué et protégé par une croûte calcaire dure forme des plateaux parfaitement plats ; le recoupement des couches par la surface topographique est manifeste. L'existence d'une surface d'érosion ancienne est donc ici évidente [1]. L'on peut inférer légitimement de cette constatation que cette surface n'était pas limitée à ce seul secteur mais qu'elle se prolongeait tout le long de la chaîne ; les crêtes subhorizontales de la partie Ouest se seraient formées à ses dépens et en constitueraient l'ultime reste. Vers l'Est la surface s'interrompt brusquement le long de la rivière Kataroktis par un abrupt qui domine un immense glacis-terrasse (région de Kharja-Ayios Amvrosios). A Kalorka, celui-ci a été repris à son tour par une autre terrasse d'altitude relative plus faible.

Des phénomènes semblables se suivent encore plus loin vers l'Est et jusqu'au début de la péninsule de Karpas.

3. Le piémont méridional (ou partie Nord de la Mésaorée).

Ce piémont est limité au Nord par la chaîne de Kyrénia, au Sud par les rivières Serakhis, Ovgos et Pedieos. Il s'est développé dans le flysch (*Kythrea Formation*) et aussi dans les couches qui lui sont inférieures (*Ovgos Formation*) et supérieures (gypse).

Les couches ont été reployées en plis nombreux et serrés dont les axes sont parallèles à celui de la chaîne de Kyrénia.

Ces plis ne se traduisent d'aucune façon dans le relief à l'exception de l'anticlinal d'Ovgos qui donne une arête légèrement en saillie dans le paysage. Ils ont été en effet manifestement pénéplanés. Aux deux extrémités de la Mésaorée, ils ont été en outre recouverts par les couches transgressives du Pliocène qui sont subhorizontales ou en pendage lent vers l'Ouest, le Sud ou le Sud-Est. L'érosion les a attaquées et y a dégagé des plateaux entourés de corniches (région de Myrtou-Ayia Marina),

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[1] E. de Vaumas. Sur la surface d'érosion pontienne de la chaîne de Kyrénia et de la péninsule de Karpas (Chypre). *Comptes rendus des séances de l'Académie des Sciences,* Tome 248, p. 121-123. 5 Janvier 1959.

de cuestas (cuesta Kyra-Dhenia-Mammari-Nicosie) ou d'éléments de crêts (Lefkoniko-Trikomo-Ayios Theodoros-Galinoporni).

Le travail de l'érosion ne s'est pas limité à dégager les formes structurales dont il vient d'être question. Partout où le flysch affleure, le ruissellement a modelé tout un système de terrasses étagées depuis la limite de la montagne (1000/1200 pieds) jusqu'à la plaine de remblaiement qui se trouve dans la partie la plus creuse de la Mésaorée. On y distingue au moins 3 ou 4 niveaux recouverts le plus souvent d'une pellicule plus ou moins épaisse de cailloux roulés. Les niveaux les plus élevés sont maintenant découpés en bandes et en buttes témoins allongées et au sommet plat, perpendiculaires à l'axe de la chaîne de Kyrénia ; les niveaux les plus bas s'étalent au contraire largement et insinuent leurs terrasses vers l'amont le long des rivières.

Par endroits, l'érosion a atteint un stade encore plus avancé. Elle a déblayé les couches tendres du flysch, fait saillir ses couches dures et engendrer d'innombrables petites crêtes et cuestas. Celles-ci s'orientent parallèlement à la chaîne de Kyrénia et constituent ces zones désolées et dépourvues de villages que traversent les routes de Nicosie à Kyrénia et de Lefkoniko à Akanthou. Il est à remarquer que les assises gypsifères qui terminent la série du flysch ont été respectées par la dénudation. Elles forment une série de collines allongées que l'on retrouve depuis Kondemenos jusqu'au Nord de Yerolakko et depuis Trikomo jusqu'à Ayios Theodoros.

II. LE MASSIF DU TROODOS ET SES BORDURES.

Bâti de roches très résistantes (diabase gabbro, péridotite, dunite,...) et d'autres qui le sont moins (pillow-lavas) et qui sont disposées en auréole autour des premières, le massif du Troodos passe d'une orientation O.N.O.-E.S.E. dans sa partie occidentale à une direction O.-E. dans sa partie orientale. Disparaissant après le piton de Stavrovouni, la chaîne semble réapparaître dans le bombement de Troulli et peut-être dans les hauteurs de Phano un peu au Nord du cap Greco.

Comme la chaîne de Kyrénia, son axe montre une orientation taurique évidente.

Dans le sens transversal, le massif manifeste une très grande dyssymétrie. Son versant Nord a 10 ou 15 km. de large tandis que le versant Sud a de 20 à 30 km., le rapport est en général de 1 à 2. En outre, le premier a été complètement dépouillé de sa couverture sédimentaire alors que le second voit celle-ci monter jusqu'à plus de 3700 pieds. Cette dyssymétrie paraît actuellement difficile à expliquer mais n'en constitue pas moins cependant un trait fondamental de la structure et du relief du Troodos.

1. Le massif cristallin.

Il forme l'ossature de la montagne et son influence est partout présente, même lorsqu'il n'est pas visible. C'est lui qui donne toutes les parties hautes de la chaîne. Bien que ses roches soient d'origine volcanique et qu'il ne laisse affleurer nulle part le socle lui-même, sa structure et sa morphologie font penser invinciblement à celle d'un massif hercynien. On y retrouve les mêmes traits classiques du relief :

— vieilles surfaces d'érosion déformées comme celles qui s'étendent sur le sommet du Troodos (Khionitsa) ou sur la partie haute de « Limassol Forest ».

— reliefs très murs que l'on retrouve sur les crêtes les plus hautes, qu'il s'agisse de l'arête faitière ou des arêtes transversales qui s'y branchent. Le fait est particulièrement frappant dans la région d'Amiandos Kyperounda-Agros-Ayios Theodoros.

— vallées emboîtées les unes dans les autres avec au stade ultime une gorge de rajeunissement actuel dont le profil dessine un V aigu.

— failles nombreuses. A ce point de vue, il faut remarquer cependant que, — à une exception près, — les failles n'ont qu'un rôle structural et morphologique mineur. Ce ne sont pas elles qui déterminent les contours du massif, elles ne l'ont pas fractionné non plus en blocs distincts les uns des autres comme cela se voit dans le monde hercynien d'Europe ou même en Asie mineure occidentale. Il existe cependant une exception comme on l'a signalé : celui de la région de « Limassol Forest » qui semble avoir été abaissé en bloc par rapport à l'ensemble du massif.

Une suite de talwegs étonnamment rectilignes (Akapnou, Ephtagonia, Arakapas, Athrakos, Kalokhorio) le sépare du reste de la montagne et suggère qu'il doit exister une grande fracture qui se prolonge d'ailleurs peut-être encore plus loin vers l'Ouest.

2. La zone des cuestas.

Un autre trait qui rapproche le massif du Troodos des massifs hercyniens est la morphologie développée sur son revers méridional. Celui-ci est encore recouvert par une série sédimentaire qui va du Crétacé au Pliocène ; les couches plongent avec une grande régularité sauf dans l'arrière pays de Paphos et de Polis où la présence de la *Mammonia Formation* amène des perturbations dans la structure et le relief.

L'évolution morphologique a opéré ici comme elle a coutume de le faire autour des massifs anciens. Le contact même du massif est souligné par une dépression périphérique qui se suit sur plus de 80 km. depuis Pano Lefkara jusqu'aux environs de Polis ; au-dessous de « Limassol Forest », cette dépression est très large et entaillée par de nombreuses terrasses. Puis viennent les grandes cuestas crétacée, miocènes et pliocène qui sont particulièrement continues et bien développées à l'Ouest de Limassol. A l'Est de cette ville, elles s'amenuisent ou disparaissent par suite de l'avancée du massif cristallin vers le Sud. Elles reprennent avec beaucoup de vigueur à l'extrémité orientale du massif autour de laquelle elles sont disposées en auréoles concentriques. Enfin la cuesta crétacée se montre une dernière fois à la faveur du bombement de Troulli qu'elle entoure d'une enceinte circulaire, dessinant ainsi un bray magnifique.

A noter enfin parmi les grandes formes de relief de cette région :

— les terrasses marines dont l'existence n'est interrompue que dans la région Episkopi-cap Aspro, elles montrent des formes remarquablement conservées de part et d'autre de Paphos.

— la péninsule d'Akrotiri, exemple tout à fait typique d'île raccordée à la terre par deux cordons de galets entre lesquels le colmatage ne s'opère que lentement et demeure encore inachevé comme en témoigne le grand lac qui y subsiste encore.

3. Le piémont septentrional (ou partie Sud de la Mésaorée).

C'est une des régions les plus intéressantes de Chypre, une de celle qui est susceptible d'apporter le plus de données sur l'évolution morphologique de l'île.

A. *Le piémont d'érosion.*

Le Troodos est bordé au Nord par des collines parmi lesquelles se voient parfois des replats plus ou moins étendus. Cette zone coïncide avec les affleurements de pillow-lavas et ne mord que rarement et très peu, bien que cela arrive, sur les roches résistantes du massif lui-même. Presque toujours ces roches marquent topographiquement la vraie limite du massif montagneux qui commence à s'élever alors brusquement.

Si l'on fait abstraction par la pensée des talwegs qui séparent les collines et les replats dont il vient d'être question, on s'aperçoit alors que cette région forme une surface d'aplanissement qui descend de 1500 pieds environ en bordure de la montagne à 1000 pieds à peu près du côté de la Mésaorée proprement dite. La reconstitution d'une surface primitive unique qui peut sembler très hypothétique ne l'est pas en réalité du fait que ce piémont rocheux conserve encore des éléments de couvertures anciennes : lambeaux de Crétacé et de Miocène, restes surtout d'une grande nappe alluviale relativement récente.

Concrètement, cette surface d'aplanissement qui se présente comme une bande étroite (5 km. en moyenne) le long du massif est un pédiment. On y retrouve les caractéristiques classiques de cette catégorie de relief : cônes rocheux dont le sommet est au débouché des vallées de la montagne, rentrants (*embayments*) dans celle-ci aux points où précisément les rivières en sorte, reliefs résiduels dus à des affleurements de roche plus résistante (crêts calcaires près d'Ambelikou et de Mitsero, sommets de Xylias et de Stavrovouni à l'Est). Il se prolonge au Nord par une région très différente.

B. *Le piémont construit.*

Au piémont rocheux, fait suite vers le Nord un piémont construit qui correspond à la partie méridionale de la plaine de la Mésaorée.

L'expression de piémont construit n'est pas en tous points parfaite. La surface d'aplanissement du piémont rocheux se poursuit en effet sur les assises pliocènes recouvertes par la nappe alluviale dont il va être question, ces assises affleurent même par endroits là où la nappe a été déblayée par l'érosion. L'expression est cependant commode et définit bien l'ensemble du relief.

Ce relief est en effet en dépendance d'une énorme masse de matériaux roulés qui, débouchant des vallées, s'est répandue en cônes très vastes sur le piémont rocheux d'abord où ils subsistent à l'état de lambeaux et dans la plaine proprement dite ensuite où ils cachent presque partout les couches pliocènes. Leur calibre est quelquefois considérable et mesure jusqu'à 2 m. de diamètre ; ils vont en s'amenuisant vers l'aval ; l'épaisseur de la nappe peut atteindre plusieurs mètres. D'après M^r Gass, ces matériaux se sont déposés en partie sous la mer ; les cônes alluviaux sont donc en partie deltaïques. Ils marquent la reprise intense de l'érosion qui a creusé les vallées du Troodos au moment de la régression de la fin du Pliocène, période qui à Chypre comme en Syrie, Liban, Palestine, voit se produire les grands mouvements orogéniques qui ont donné naissance à la structure et au relief actuels.

Morphologiquement ces cônes ne se présentent pas de la même façon. De la baie de Morphou à la rivière Péristerona, leur surface terminale a été conservée dans l'ensemble ; à l'Est de cette rivière, ils ont été au contraire profondément disséqués par l'érosion et ont fait place à des lanières groupées en éventail, à des collines à sommet plat, à des terrasses fluviales, à des crêts et à des glacis. Il ne fait pas de doute que l'analyse et la cartographie détaillée de ces formes ne permettent de reconstituer avec beaucoup de précision l'évolution morphologique de Chypre.

Il est à remarquer que le piémont construit le mieux conservé se trouve à l'Ouest, c'est-à-dire sous le sommet actuel du massif tandis que celui qui a été le plus morcelé se situe à l'Est sous le Troodos oriental qui est nettement moins élevé mais beaucoup plus disséqué par contre que le Troodos occidental.

Cette constatation comme celle aussi que l'ensemble des cônes du piémont construit est centré sur la partie orientale du massif montre que celle-ci a dû constituer originellement la partie la plus soulevée de la montagne.

III. LES PLAINES DE REMBLAIEMENT ALLUVIAL.

Entre les deux grandes régions morphologiques dont il vient d'être question (chaîne de Kyrénia et massif du Troodos), s'insinuent à chaque extrémité de la Mésaorée deux plaines qui ne relèvent directement ni de l'une ni de l'autre.

La Mésaorée a été occupée au Pliocène par un bras de mer qui s'étendait presque d'une chaîne à l'autre. Au moment des grands mouvements orogéniques, une exondation complète s'est produite au centre de la dépression, exondation qui était puissamment aidée par la mise en place de la nappe alluviale. Aux deux extrémités cependant, l'ancien bras de mer subsistait et les baies de Morphou et de Famagouste ont dû jusqu'à une date tardive du Quaternaire s'avancer beaucoup plus profondément à l'intérieur des terres qu'elles ne le font à l'heure actuelle. L'exondation ici est beaucoup moins consécutive aux mouvements orogéniques qu'à un remblaiement alluvial récent et d'ailleurs non terminé.

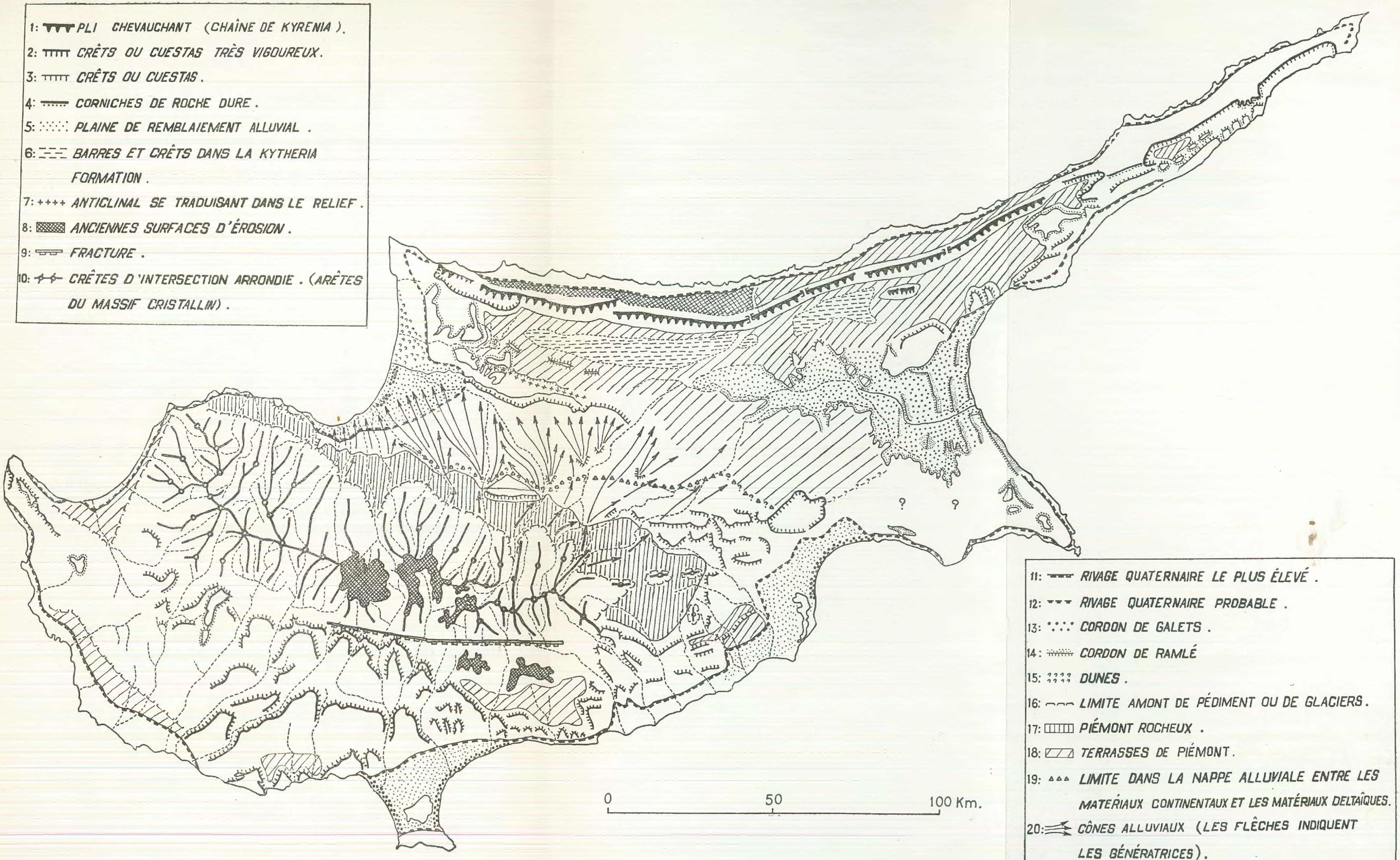
La baie de Morphou a été barrée par un cordon de galets dont on voit les traces de Ghaziveran à Syrianokhori, ces galets étaient mis en place par le courant qui longe la côte du Sud au Nord et qui déposaient les matériaux des rivières de la côte de Tylliria. En arrière de ce cordon s'opérait un colmatage par les alluvions venues du Troodos et aussi (mais surtout au Nord de Syrianokhori) par les sables poussés par les grands vents d'Ouest. Le caractère récent de ce colmatage ressort de ce fait que subsistent encore dans cette région des zones marécageuses.

L'évolution de *la baie de Famagouste* a été similaire à quelques détails près. Aucun cordon de galets n'y est décelable comme dans la baie de Morphou ou dans la péninsule d'Akrotiri. Par contre, toute une série de crêtes basses s'y observent qui barrent la plaine entre le piémont de la chaîne de Kyrénia et la grande avancée des terres qui aboutit au cap Greco. Ces crêtes ont toutes la même structure et la même morphologie : elles sont dyssymétriques, montrant un versant court et escarpé à l'Ouest, un versant long et en pente douce à l'Est ; elles sont construites avec du sable concrétionné, leur stratification est inclinée vers la mer et les couches se présentent comme des assiettes emboîtées les unes dans

les autres, les plus anciennes à l'Ouest, les plus récentes affleurant sous la mer sous forme de barres de récifs. Cette structure et cette morphologie sont exactement semblables à celles qu'on observe le long des côtes de la Méditerranée orientale depuis la Cilicie jusqu'à l'Egypte quoiqu'ordinairement à une échelle beaucoup plus réduite. La baie de Famagouste très étroite a été vite barrée à sa partie aval par le sable de la mer que le vent poussait vers l'intérieur des terres et y accumulait en cordons dunaires. Ce sable, le phénomène est courant au Levant, s'y agglutine et s'y durcit avec une très grande vitesse pour donner la pierre dure et poreuse que les Arabes appellent *Ramlé;* la grésification du sable est si rapide dans ces pays qu'on y a trouvé des tessons de poterie romaine et jusqu'à des boîtes de conserve !...

Les arêtes de grès-ramlé qui ferment la baie de Famagouste marquent donc les étapes du recul de la mer, l'existence d'un port à Alasia (Engomi) à 3 km. de la mer durant l'époque du Bronze permet de se faire une idée de la rapidité du recul de la mer qui doit se poursuivre toujours. Quant au comblement de la nappe d'eau laissée à l'arrière des anciens cordons littoraux, elle n'a dû se faire que lentement ; les apports de matériaux alluviaux ne peuvent provenir ici que de la seule chaîne de Kyrénia, ils sont donc beaucoup moins importants qu'à l'Ouest ; d'autre part, l'ancienne surface à combler est très vaste (40 km. de longueur sur 5 à 10 km. de largeur). Cela explique que le remblaiement à peu près réalisé à l'Ouest l'est encore très mal à l'Est où l'on a dû effectuer de nombreux travaux de drainage. La permanence de l'alluvionnement se poursuit cependant, il est attesté par le pont de Prastio où le remblaiement atteint maintenant les arches.

E. DE VAUMAS


1: PLI CHEVAUCHANT (CHAÎNE DE KYRENIA).
2: CRÊTS OU CUESTAS TRÈS VIGOUREUX.
3: CRÊTS OU CUESTAS.
4: CORNICHES DE ROCHE DURE.
5: PLAINE DE REMBLAIEMENT ALLUVIAL.
6: BARRES ET CRÊTS DANS LA KYTHERIA FORMATION.
7: ANTICLINAL SE TRADUISANT DANS LE RELIEF.
8: ANCIENNES SURFACES D'ÉROSION.
9: FRACTURE.
10: CRÊTES D'INTERSECTION ARRONDIE. (ARÊTES DU MASSIF CRISTALLIN).
11: RIVAGE QUATERNAIRE LE PLUS ÉLEVÉ.
12: RIVAGE QUATERNAIRE PROBABLE.
13: CORDON DE GALETS.
14: CORDON DE RAMLÉ.
15: DUNES.
16: LIMITE AMONT DE PÉDIMENT OU DE GLACIERS.
17: PIÉMONT ROCHEUX.
18: TERRASSES DE PIÉMONT.
19: LIMITE DANS LA NAPPE ALLUVIALE ENTRE LES MATÉRIAUX CONTINENTAUX ET LES MATÉRIAUX DELTAÏQUES.
20: CÔNES ALLUVIAUX (LES FLÈCHES INDIQUENT LES GÉNÉRATRICES).
0
50
100 Km.
?
?

STRATIGRAPHIC AND LITHOLOGIC RECONNAISSANCE STUDIES IN NORTHERN IRAQ

BY

RAOUL C. MITCHELL

INTRODUCTION

That part of Northern Iraq bordering Turkey is little known geologically. This rugged mountain area is difficult of access, mule-tracks the only means of travel, a region prohibitive of field work during the winter season of deep snows and gale-force winds. As far as the writer is aware, no publication has appeared to date treating the geology of this area. The Iraq Petroleum Co. Ltd., have made brief studies and palaeontological determinations, and the Sites Investigations Co. Ltd. have made some reconnaissance surveys connected with assessments of the economic mineral potentialities.

During the past few years, the writer has visited this northern area on several occasions. Systematic surveys have not been attempted, due to lack of time, but the opportunity was taken to gain some field acquaintance with the geology.

FIELD STUDY

In this magnificent mountain terrain of bare, rocky slopes, towering precipices, impressive gorges, rock sections are displayed with unusual clarity. In the Folded Zone, the ranges and valleys reflect the anticlinal and synclinal structure in excellent fashion. Wandering over the area, the writer located what appeared good representative sections of the various stratigraphic units. Measured sections were chosen more on the basis of being able to locate the top and bottom of the stratigraphic unit and where the structure did not appear to have caused any duplication or omission. The measurements recorded make no claim as

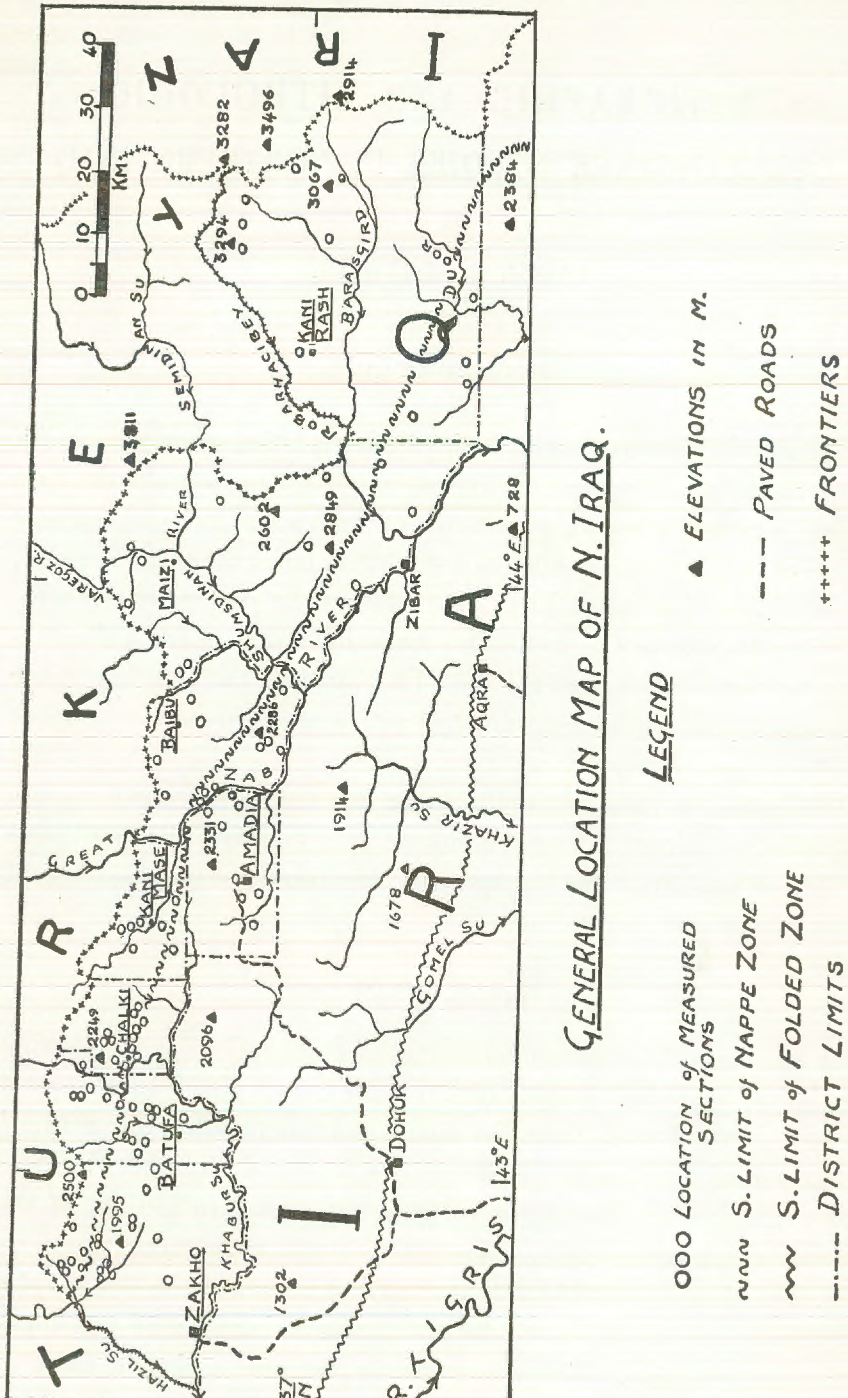


FIG. 1.

indicating maximum thicknesses, but on the other hand, they do suggest relative thicknesses throughout the area of various formations.

For convenience of treatment, the area can be divided into eight districts, from west to east, named after the chief town and/or administrative centre, viz : Zakho, Batufa, Chalki, Kani Mase, Amadia, Baibu, Maizi and Kani Rash. A total of 93 formational sections have been measured.

STRUCTURE

It is not intended to discuss the structural complexity, but a word would be in order.

In the central part, the strike is generally E.-W., swinging to N.W.-S.E. at the western end and from N.W.-S.E. to N.N.W.-S.S.E. at the eastern end. On a structural basis, the region can be divided into two major provinces : (1) South from the Turkish border lies a zone in which southward-directed thrusting of older strata against younger takes place. This possibly correlates with the Nappe Zone further south. (2) South of the above zone occurs a region of broad, long anticlinal folds forming the ranges, separated by wide synclinal valleys, constituting the Folded Zone. In the Nappe Zone two important thrusts are found, both of which bring Cretaceous or older beds in contact with strata ranging from Triassic to Miocene. Both thrust planes dip steeply to the north, horizontal translations amounting to as much as 5.5 km. Frequently wrench and strike-slip faults cause offsetting up to 2 km.

STRATIGRAPHY

Table 1 shows the stratigraphic column for the region. The oldest rocks belong to the Ora Shale Series. The relatively few *Spirifer* and *Coelenterata* which have been found to date prohibit precise dating, the Series being considered to range from Ordovician (?) to Lower Carboniferous. Nowhere is a basement observed, and hence the total thickness is unknown but it is at least 820 m. thick. The Series, as also the Chia Zairi Dolomite, is missing from the central districts where the structure

is more complicated and where lateral translation faulting is common. The Chia Zairi Dolomite appears to be largely Permian, but the lower shale horizons may be Upper Carboniferous. The Sirwan Formation has three diagnostic subdivisions; a lower one comprising chiefly shales, clays and marls, a middle one of marly shales and argillites and an upper

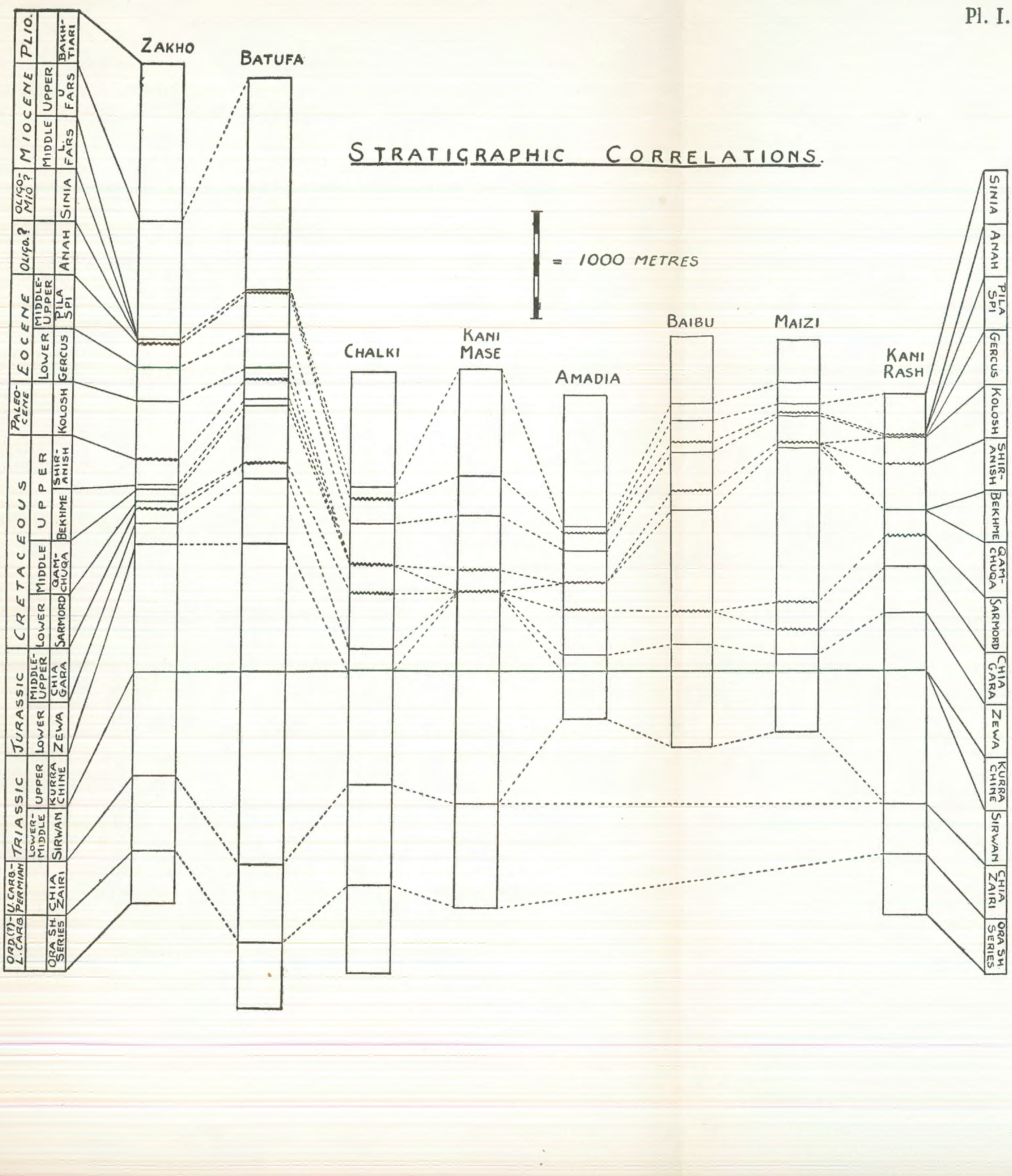
TABLE 1

Stratigraphic Column

System	Series	Formation	Thickness in m.
Quaternary		River terrace deposits	3-35
Pliocene		Bakhtiari Series	1480
Miocene	Upper	Upper Fars Series	410-2000
	Middle	Lower Fars Series	60-1000
Oligo-Mioc.?		Sinia Tuffs	70-375
Oligocene?		Anah Limestone	35-50
Eocene	Upper-Middle	Pila Spi Limestone	15-390
	Lower	Gercus Beds	250-500
Palaeocene		Kolosh Formation	110-540
Cretaceous	Upper	Shiranish Marls	185-425
		Bekhme Limestone	45-200
	Middle	Qamchuqa Limestone	110-1450
	Lower	Sarmord Limestone	70-280
Jurassic	Upper-Middle	Chia Gara Series	150-525
	Lower	Zewa Formation	150-610
Triassic	Upper	Kurra Chine Dolomite	740-1200
	Middle-Lower	Sirwan Formation	450-1800
U.Carbon.(?) -Permian		Chia Zairi Dolomite	470-965
L.Carbon.- Ordov.(?)		Ora Shale Series	480-820

one of limestones and dolomites. The top of the Sirwan provides the best 'marker horizon'. Not only is the Sirwan well developed throughout the entire region but also the upper calcareous rocks have a persistent grey to black colour, comprise cherty dolomitic limestones with a strong organic or fetid odour. The Kurra Chine Dolomite is lighter in colour than the upper calcareous rocks of the Sirwan Formation, have a very slight or no organic odour. The Kurra Chine is only known in the western part, but in the east it may be that some basal Zewa dolomites should be assigned to the Kurra Chine. The Zewa Formation and the Chia Gara Series are abundantly fossiliferous—ammonites especially numerous—and no doubt in the future it should be possible to establish several subdivisions and more minute faunal zones. The absence of these two units in the Kani Mase district is believed to be due to structural rather than stratigraphic causes, as east and west of the district they are well developed and show no indications of gradual lensingout. The prevalence of gravity and/or normal faulting in this district has probably lowered them out of sight. The Sarmord Limestone is difficult to distinguish from the Qamchuqa Limestone in places, but in general, the former tends to show thinner beds, has numerable shale partings and a bituminous characteristic is common. In the Zakho district, the Sarmord rests disconformably on the Chia Gara, but in the Maizi district there is a slight angular unconformity between these two formations. In the eastern districts the Sarmord is much more hetergeneous lithologically and much thicker than at Zakho. The Qamchuqa Limestone is everywhere—except in Zakho—in unconformable relationship with the underlying beds. Throughout the whole area, the Qamchuqa plays a decisive structural rôle, the hard, tough, massive limestones and dolomites offering relatively great resistance to any moulding efforts, but rupture by means of shears instead. In general, the formation acts as a competent strut. The Upper Cretaceous includes the Bekhme Limestone and the Shiranish Marls, both belonging to the Maestrichtian. In the west, the Bekhme is predominantly calcareous whereas the Shiranish consists largely of marls, shales, argillites, clays; in the east, on the other hand, the situation is reversed. In the Batufa district there appears to be interdigitation between the two. At present, the drawing

of formational boundaries between the Bekhme and Shiranish seems rather dubious and they more likely represent facies changes. The Kolosh Formation upon closer study will probably prove to be a basal rudaceous and arenaceous development of the Gercus Beds. Coarse clastics are very common, frequently occurring in huge lenses. Everywhere it was noted that the Kolosh rests with angular unconformable relations on the beds beneath. The Gercus Beds have a characteristic red colouration, but greens, purples, browns, yellows make this a gaudy formation. The problem of the significance of red colouration need not detain us, but the presence of evaporites in the Gercus—gypsum and highly gypsiferous shales and clays are more abundant in the Gercus than other formations—would seem to require an excess of evaporation in remnant lagoonal areas as also in residuary seas, all of which suggests chemical changes either during or subsequent to sedimentation under arid or then semi-arid environments. The Pila Spi is well developed in the west, but east of Amadia it thins greatly. In Kani Mase district the Pila Spi in places has a biohermal character of crinoidal and coral banks. The Anah Limestone is of questionable age. In Zakho and Batufa districts it conformably underlies the well-established Upper Miocene Upper Fars and disconformably rests on the Pila Spi. It is provisionally assigned to the Oligocene but may be Upper Eocene or even part of the Middle Miocene Lower Fars. The Sinia Tuffs, which comprise acidic tuffs, shales and cherts principally, are only found in the east. Further south lava flows and pyroclastics are probably of Eocene age, but in the districts here considered, the Tuffs lie unconformably on the Pila Spi as also the Gercus Beds. However no contacts have been observed between the Tuffs and the Fars. Tentatively the Tuffs are called Oligocene-Miocene (?), but this is not proven. The Lower and Upper Fars, as well as the Bakhtiari Series, are well known in the literature and have been closely studied by the oil companies, consequently need no further comment. Though these formations were not seen in the Kani Rash district, their absence cannot be taken for granted. This district is the least accessible of all, travel is a laborious and tedious matter, and the writer has less acquaintance with this district than any other. Quaternary fluvial deposits form prominent


STRATIGRAPHIC CORRELATIONS.
= 1000 METRES
ZAKHO
BATUFA
CHALKI
KANI MASE
AMADIA
BAIBU
MAIZI
KANI RASH
ORD.(?)-L.CARB
U.CARB.-PERMIAN
TRIASSIC
LOWER-MIDDLE
UPPER
JURASSIC
LOWER
MIDDLE-UPPER
CRETACEOUS
LOWER
MIDDLE
UPPER
PALEOCENE
EOCENE
LOWER
MIDDLE-UPPER
OLIGO.?
OLIGO-MIO?
MIOCENE
MIDDLE
UPPER
PLIO.
ORA SH. SERIES
CHIA ZAIRI
SIRWAN
KURRA CHINE
ZEWA
CHIA GARA
SARMORD
QAM-CHUQA
BEKHME
SHIR-ANISH
KOLOSH
GERCUS
PILA SPI
ANAH
SINIA
L. FARS
U FARS
BAKH-TIARI

river terraces along most of the larger rivers, varying in thickness from 3 to 35 m.

LITHOLOGIC ASPECT

Table 2 succinctly expresses the lithological variations observed throughout the region. (The term lithofacies, having as many interpretations as there are users of the expression, had better be ignored in the literature.) For each stratigraphic unit, lithologic ratios were determined. The clastic ratio represents the thickness of clastics divided by the thickness of the non-clastics. The clastics comprise what are generally understood to be detritals or débris of other rocks. It should be mentioned, however, that contrary to some opinions, the writer has included marls with the clastics. There admittedly mixed type of shales and clays within this area of northern Iraq show a relatively weak carbonate content, and are thus more closely allied to the argillaceous rocks. This essential division of the rocks into clastics and non-clastics defines the physico-chemical environment of sedimentation. As the clastics include a considerable range of rock types, the clastic ratio is not sufficiently definitive. The clastics therefore have been further subdivided on the basis of particle size into psephites, psammites and pelites. The thickness of the psephites plus psammites divided by the pelites gives the psephite-spammite/pelite ratio. Such a ratio brings out the physical character of environment of deposition as well as erosion

The non-clastics comprise rocks formed principally of chemical or biologic material. It follows, therefore, that the physio-chemical and biochemical requirements and conditions of the solution medium play a far more important rôle than the purely physical (mechanical) agencies responsible for the clastics. Further refinement of the non-clastics was not deemed necessary, as the overwhelming proportion of these comprise dolomites and limestones. Evaporites and such other non-clastics as siliceous, ferruginous, organic sediments are of no statistical significance in this area. The calcareous non-clastics include dolomite, dolomitic limestone, crystalline limestone, foraminiferal limestone, oolitic limestone. Other fossiliferous limestones and chalk are not common. Impure

TABLE 2

FORMATIONS	ZAKHO THICK. M.	ZAKHO CL. RAT.	ZAKHO PP/P RAT.	BATUFA THICK. M.	BATUFA CL. RAT.	BATUFA PP/P RAT.	CHALKI THICK. M.	CHALKI CL. RAT.	CHALKI PP/P RAT.	KANI MASE THICK. M.	KANI MASE CL. RAT.	KANI MASE PP/P RAT.
BAKHTIARI	1480	·49	13									
U. FARS	1100	11·5	·28	2000	50	·13	1080	24	·66			
L. FARS							110	·43	·03	1000	·66	·06
SINIA												
ANAH	50	0	~	35	0	~						
PILA SPI	220	·03	18	390	·01	4·6	240	·12	6·6	375	·09	2·1
GERCUS	310	61	1·7	320	49	1·1	375	36	·47	500	8	·40
KOLOSH	540	9	49	110	13·3	15·6						
SHIRANISH	240	9	·03	185	11·5	·04						
BEKHME	45	·07	9	65	0	~				200	·08	·17
QAMCHUQA	110	·02	0	540	·03	·23	280	·03	·81			
SARMORD	70	·30	·66									
CHIA GARA	150	·21	·09	155	·13	·17	525	·26	·49			
ZEWA	200	·07	0	610	·09	2·0	195	·01	7·8			
KURRA CHINE	1200	·05	·08	1200	0·2	·58				740	·09	·78
SIRWAN	975	·53	·15	1800	1·9	·04	1060	1	·11	1240	·69	·53
CHIA ZAIRI	700	·17	6·62	725	·04	·16	930	·03	10·1	965	·03	15·6
ORA	480	79	·25	600	11·5	·09	820	9	·06			

FORMATIONS	AMADIA THICK. M.	AMADIA CL. RAT.	AMADIA PP/P RAT.	BAIBU THICK. M.	BAIBU CL. RAT.	BAIBU PP/P RAT.	MAIZI THICK. M.	MAIZI CL. RAT.	MAIZI PP/P RAT.	KANI RASH THICK. M.	KANI RASH CL. RAT.	KANI RASH PP/P RAT.
BAKHTIARI												
U. FARS	1230	5·2	1·7	620	19·6	·85	410	15·4	4·3			
L. FARS	60	·88	·12	160	1·8	·03	190	5·33	·45			
SINIA				200	19	1·2	70	34	1·42	375	25·6	3·05
ANAH												
PILA SPI	165	·15	·56	90	10·1	·81	35	·74	1·5	15	·66	3
GERCUS	290	6·1	·85	350	10·1	·82	250	8	2			
KOLOSH										240	3·3	12·33
SHIRANISH										425	·11	·50
BEKHME				180	·12	·47	50	1·15	·15			
QAMCHUQA	250	·06	·02	950	·16	1	1450	·11	1·14	250	·08	3
SARMORD							250	·89	1·36	280	1·25	·66
CHIA GARA	420	·33	·16	310	6·7	·09	230	1·18	·44	430	1·2	·66
ZEWA	150	·09	·72	250	·13	·21	160	·20	·50	540	·91	·33
KURRA CHINE												
SIRWAN	450	·25	·08	720	·91	·45	570	·83	·13	1240	1·3	·88
CHIA ZAIRI										470	·04	·33
ORA										560	11	1·29

LITHOLOGIC ASPECT OF FORMATIONS.

varieties of limestones especially are sporadic in occurrence, calcarenites of siliceous type being commonest. Metasomatism of the limestones is of frequent occurrence. Many dolomites and dolomitic limestones are of black colour, and bituminous varieties are quite common. Of the evaporites, gypsum is the only one of importance. As would be expected anhydrite outcrops are very rare, but some halite beds measuring 2 m. thick have been observed in the Gercus Beds. Siliceous sediments, chiefly chert, have few pure occurrences, though cherty and flinty dolomites and limestones are known through the area.

CONCLUSION

The information presented above can only be considered as an initial attempt to portray some of the geology of this little known but vastly interesting region. If there be truth in the aphorism « C'est le premier pas qui coûte», then perhaps some incentive may have been given to the many problems which await elucidation in this land of the staunch, hospitable Kurds.

وقد وصف المؤلف هذه الأشكال وصفاً تحليلياً فى ضوء زيارته للمنطقة ، فعالج الأشكال المرتبطة بالصخور المتحولة والصخور الجرانيتية ، وتلك التى تكونت فى الحجر الرملى المعروف بخرسان عديجرات ، وفى اللافا بنوعيها البازلت والتراكيت .

وعالج فى الوقت نفسه عدداً من المشكلات المورفولوجية فى المنطقة أهمها :

(ا) أصل الجرف العظيم الذى يحد الهضبة الأثيوبية من الشرق . هل يعتبر جرفاً انكسارياً يمثل جزءاً أصيلا من الشفرة الغربية لأخدود البحر الأحمر ، أم أنه ظاهرة تحاتية فى المقام الأول .

(ب) منطقة أسمرة التى تبدو عليها مظاهر الشيخوخة . هل تعتبر سهلا تحاتياً ظل منكشفاً منذ أن تكوّن خلال الزمن الأول ، أم أنها تمثل سهلا تحاتياً حفرياً انكشف بعد زوال غطائه البازلتى .

(ج) المرتفعات التراكيتية فى منطقة صنعافة ، هل تعتبر أشكالا تحاتية أم أشكالا بنيوية .

وختم المؤلف بحثه بتلخيص للتاريخ التحاتى للمنطقة ينقد خلاله الرأى القائل بتعدد الدورات التحاتية فى الهضبة الأثيوبية بعد تكون السهل التحاتى الباليوزوى .

الأستاذ اتيين دى فوماس : الأقاليم المورفولوجية الكبرى لجزيرة قبرص :

درج الدارسون إلى تقسيم جزيرة قبرص إلى أقاليم ثلاثة رئيسية وهى : سلسلة كيرنيا فى الشمال ، كتلة ترودس فى الجنوب ، وأخيراً سهل ميزاءورة ويتوسط الإقليمين السابقين .

ولئن كان هذا التقسيم صحيحاً من ناحية الجغرافية العامة إلا أن من الصعب الأخذ به من الناحية الجيومورفولوجية . ويرى المؤلف أن من الأفضل التمييز فقط بين سلسلة كيرانيا وأطرافها من ناحية ثم مرتفعات ترودس وأطرافها من ناحية أخرى ، وذلك أن إقليم ميزاءورة يمثل تقابل أقدام السلسلتين الجبليتين .

١ ــ سلسلة كيرانيا :

تمتد السلسلة مسافة ١٦٠ كيلومتراً ، وهى عبارة عن ثنية محدبة كبيرة اتجهت فيها الضغوط الجانبية ناحية الجنوب ، وبالرغم من أن الصخور تتكون من الحجر الجيرى ، إلا أن الأشكال الكارستية قليلة نظراً لضيق الجبل وشدة انحداره .

٢ ــ مرتفعات ترودس :

وتتكون من صخور قديمة والجانب الشمالى لهذه المرتفعات أكثر انحداراً من الجانب الجنوبى الذى يمتاز بغطاء من صخور رسوبية مما دعا إلى تكوين تضاريس الكويستا المعروفة .

وإلى جانب هاتين الوحدتين المورفولوجيتين يوجد فى طرفى ميزاءورة سهلان كانت تغمرهما مياه البحر فى الزمن الرابع ، ويرى المؤلف أن تكوينهما يرجع إلى الإرساب الذى لم ينته بعد ويقع السهلان فى امتداد لخليج مورفون وخليج فاماجوستا ناحية الداخل .

الأستاذ راءول ميتشيل : دراسات فى تعاقب الطبقات وطبيعة الصخور فى شمال العراق :

هذه دراسة تمهيدية للإقليم الجبلى فى شمال العراق والمتاخم للحدود التركية . ويلاحظ أن البنية هنا إلتوائية معقدة فى أقصى الشمال بسيطة إلى الجنوب .

وتنتمى صخور السلاسل الجبلية إلى الزمن الأول والثانى والثالث والرابع ، وأقدمها ما ينتمى إلى العصرين الأوردفيشى والفحمى . ولم تلاحظ أية تكوينات قديمة أركية .

وقد لخص المؤلف فى جدول خاص ملاحظاته عن التغير الذى ينتاب سمك التكوينات الجيولوجية فى مختلف الجهات .

الحولية التى تظهر فى فصل المطر ، وهذا التلف منشؤه جفاف النباتات أو اقتلاعها . ولقد كان لفعل الرمال التى تحملها الرياح أثر كبير فى هلاك الأجزاء الهوائية للنباتات .

وبدراسة كثافة النباتات ونسبة الغطاء النباتى فى منطقة معرضة للرياح وأخرى أقل تعرضاً نظراً لحمايتها بالمرتفعات التى بحدها وجد أنه عقب الرياح قد انخفض عدد النباتات مقدار ٤٩ ٪ مما كانت عليه قبل هبوب الرياح فى المنطقة المعرضة بينما فى المنطقة المحمية نسبياً بلغ النقص ٢٧ ٪ فقط . ويرجع النقصان فى عدد النباتات إلى هلاك النباتات الحولية الصغيرة وكذلك النباتات المعمرة الحديثة نظراً لقلة احتمالها . أما النباتات المعمرة البالغة لها القدرة على مقاومة فعل الرياح لخصائصها التشريحية والفسيولوجية التى تمكنها من ذلك .

أما نسبة الغطاء الكلى للنباتات فقد انخفضت عقب هبوب الرياح بمقدار ١٥ ٪ فى المنطقة المعرضة للرياح و ٥ ٪ فى المنطقة المحمية نسبياً ، ويعزى هذا النقص أساساً إلى هلاك بعض النباتات الحولية .

الدكتور عبده شطا : المياه الأرضية وجيومورفوجية القطاع الشمالى من حوض وادى العريش :

يخترق القطاع الشمالى من حوض وادى العريش السهل الساحلى لشبه جزيرة سيناء ويبلغ عرضه حوالى سبعين كيلومتراً تبدأ من مخرج خانق الضيقة حتى ساحل البحر المتوسط . وفى هذا الجزء من سيناء توجد آصرة قوية تربط بين التركيب الجيولوجى العام والظواهر المورفولوجية الموجودة .

يتميز وادى العريش فى هذه المنطقة الساحلية ، وهى تكوّن جزء من المنخفض التركيبى الذى يقع على الحافة الشمالية لطية الحلال والمغارة ، بعدم وجود روافد عديدة تتصل به وهو يمر فى طبقات طفلية ورملية تتبع الحقب الرباعى ترقد مباشرة فوق طبقات عديدة تشمل الكريتاسى العلوى والأيوسين والميوسين وأخيراً البليوسين .

وعلى جانبى مجرى الوادى الحالى أمكن تمييز وتتبع ثلاث شرفات تدل على المظهر المورفولوجى الحديث للسطح . ويرجع تكوّن هذه الشرفات إلى الهبوط التدريجى فى مستويات الوادى القديم ، هذا الهبوط الذى بدأ يتخذ شكلا ملحوظاً فى خلال فترة الهولوسين .

ولقد كانت الدراسات المورفولوجية هذه مفيدة بالنسبة للتعرف على الموارد المؤثرة فى الإمكانيات المائية للمنطقة .

الدكتور عبده شطا : المشاكل الجيولوجية المتصلة بالموارد المائية لبعض المناطق الصحراوية :

فى خلال السنوات الخمس الماضية اضطلع القسم الجيولوجى بمعهد الصحراء بدراسة بعض المناطق الصحراوية للتعرف على العوامل الجيولوجية والمورفولوجية المؤثرة فى إمكانيات المياه الجوفية والأراضى . ومن بين المناطق التى تمت دراستها ما يلى :

أولا — منطقة العامرية مريوط إلى القرب من الأسكندرية .
ثانياً — المنطقة التى تقع بين مديرية التحرير ووادى النطرون .
ثالثاً — منطقة الواحات الخارجة والداخلة .
رابعاً — منطقة حوض وادى العريش بشمال سيناء .
خامساً — منطقة قطاع غزة بفلسطين .

الدكتور يوسف أبو الحجاج : حول مورفولوجية الهامش الشرقى لهضبة أثيوبيا :

يتمثل فى هذه الهضبة جميع أنواع الصخور التى تظهر فى سطح الهضبة الأثيوبية تقريباً ، وتتنوع تبعاً لذلك أشكال السطح فيها بحيث يمكن اعتبارها نموذجاً جيومورفولوجيا مصغراً لهذه الهضبة .

عن حل مشاكلها وكاتب هذه الرسالة الذى قضى فترة طويلة من حياته فى العمل بالصحارى المصرية وصحراء بلاد العرب والأردن ، بينما زار الجزائر وتونس سنة ١٩٥٠ موفداً من الحكومة المصرية يرى من الواجب عليه أن يضع نتيجة خبرته فى عمله أمام القارىء فى المواضيع الآتية :

١ — الرى من الأنهار .

٢ — العقد (سد حجرى صغير) .

٣ — الرى الفيضى .

٤ — الكروم .

٥ — السوانى .

٦ — الآبار العميقة .

٧ — الدبول .

٨ — الرى من مياه الصرف .

٩ — سدود التخزين .

ثم تكلم عن وسائل تغذية المياه الجوفية عندما تفور بواسطة السدود السطحية والجوفية وسن التشريعات (العرف) وتكلم عن السدود الجافة التى تختزن بين حبيبات الرواسب بها ما يعادل ٢٥ ٪ من الماء ، وعن التين الشوكى الذى انتشرت زراعته أخيراً بجبال الطائف وأهميته لزيادة مياه الآبار ، وتكلم عن صرف المستنقعات لفائدة صحة البدو ، وعن أهمية وقاية المجارى من الرمال السافية وعن تبطين المجارى بالأسمنت لمنع تبديد المياه وعن المطر الصناعى وعن السناطين الذين احترفوا البحث عن الماء الجوفى وأهمية الدراسات الجيولوجية والجيوفيزيكية واستعمال ماء البحر وطرق تخليصه من الأملاح الذائبة به .

وأوضح هذه المواضيع بدراسات قام بها مثل التوسع الزراعى بالصحراء الشرقية والصحراء الغربية والواحات وعين عبد العزيز بمكة وسد الطائف وسد الرياض بوادى حنيفة وسد العاقول بالمدينة ومشروع صرف الأزرق بالأردن وسد الروافع بسيناء والآبار العميقة بالخارجة والداخلة وألحق برسالته صوراً شمسية أخذها أثناء عمله وخريطة تبين التوسع الزراعى بالصحارى المصرية من النيل .

الدكتور أحمد محمد مجاهد ، محمد الشافعى على ، عبد الرحمن أمين ، محمد أحمد حموده :
مشاهدات بيئية فى غرب وجنوب سيناء :

بين المؤلفون فى هذا البحث الأهمية الجغرافية لسيناء وطوبوغرافيتها وشكل الأرض والموارد المائية بها وناقشوا المناخ بالمنطقة وأظهروا أثر البحر والارتفاع على المناخ فى السهل الساحلى الغربى والمنطقة الوسطى .

ودرست البيئات النباتية فى سيناء وأمكن تمييز البيئات الآتية :

١ — السهول : وقد درست نباتاتها وأنواع التربة بها .

٢ — الوديان كوادى فيران ووادى غرندل والوادى المؤدى لجبل حمام فرعون ووادى الراحة ووادى الأربعين .

٣ — الجبال والمرتفعات الصخرية : وقد درست منها كأمثلة الجوانب الصخرية لوادى الراحة والجبال القريبة من دير سانت كاترين وجبل موسى والجوانب الصخرية لوادى فيران .

٤ — الواحات والعيون : درست النباتات والتربة بواحة فيران والواحات والعيون بوادى الأربعين وواحة وادى الراحة وعيون موسى .

٥ — المستنقعات الملحية : وهى توجد فى السهل الساحلى الغربى ودرس فيها المستنقع الملحى بحمام فرعون والمستنقع الملحى بوادى غرندل ومستنقع أبى زنيمة .

٦ — الكثبان الرملية : وهى توجد أيضاً بالسهل الساحلى وقد درست نباتاتها ومنها الأثل والرتم والرمث والغردق .

الدكتور عبد الرحمن أمين ، السيد / محمد نبيل الحديدى : بعض المشاهدات عن تأثير الرياح على النباتات الصحراوية بطريق السويس :

تتعرض النباتات فى الصحارى المصرية إلى رياح شديدة تسبب لها كثيراً من التلف . ولقد أجريت بعض المشاهدات فى الصحراء المصرية على طريق السويس عند الكيلو **٣٥** للوقوف على مدى تأثر النباتات بالرياح . ففى يناير عام **١٩٥٥** بلغت شدة الرياح **٥٥** كيلومتراً وترتب على ذلك تلف كبير لكثير من النباتات

٢ — الهجرة من مدينة القاهرة وإليها .

٣ — تحركات السكان فى داخل المدينة .

أما فيما يتصل بالموضوع الأول ، فقد شهدت مدينة القاهرة تزايداً سكانياً هائلا فى النصف الأول من القرن العشرين (١٨٩٧ — ١٩٤٧) ، فقد تزايد عدد السكان المطلق من ٥٩٨,٥٧٢ فى سنة ١٨٩٧ إلى ٢,٠٩٠,٦٥٤ فى سنة ١٩٤٧ ، وقفزت أيضاً معدلات التزايد السنوية من ١,٥ ٪ فيما بين ١٨٩٧ ، ١٩٠٧ إلى ٥,٩ ٪ فى فترة العشر سنوات الممتدة بين ١٩٣٧ — ١٩٤٧ . وتتضح لنا أيضاً الزيادة الهائلة التى شهدتها المدينة إذا ما عرفنا أن بعض أحيائها قد بلغت نسب الزيادة فى فترة الخمسين سنة الممتدة بين ١٨٩٧ — ١٩٤٧ أكثر من ١٠٠٠ ٪ كما هى الحال فى مصر الجديدة وروض الفرج وشبرا ، فقد بلغت نسب الزيادة فى كل منها على التوالى ١٩٢٧ ، ١١٥٦ ، ١٢٠٣ .

وعلى هذا نرى أن نمو السكان فى أحياء مدينة القاهرة يكاد — إلى درجة كبيرة — يتفق مع تحركاتهم من الأحياء المركزية — التى تمثل نواتها القديمة — إلى ضواحيها وأطرافها فى الشمال والجنوب والغرب بصفة خاصة .

أما الموضوع الثانى فيبرز دور الهجرة فى تزايد سكان المدينة وذلك بتحليل الجداول الخاصة بتوزيع السكان حسب محال الميلاد فى مديريات القطر ومحافظاته . وقد أوضح هذا التحليل أن نسبة ما جنته القاهرة من تبادل السكان بينها وبين بقية أنحاء البلاد قد ارتفعت من ٢٠ ٪ من جملة السكان فى سنة ١٩١٧ إلى حوالى الثلث فى سنة ١٩٤٧ ، وقد هاجر من المدينة فى نفس الوقت ٢,١ ٪ من « القاهريين » فى سنة ١٩١٧ ، ٤,٤ ٪ فى سنة ١٩٤٧ ، وقد بينت الدراسة أيضاً أن الدلتا قد أسهمت بحوالى ٦٧,٢ ٪ من جملة المهاجرين فى سنة ١٩٤٧ فى حين أن مصر العليا قد أضافت ٣٢,٨ ٪ فقط . ولعل هذا التفاوت يرجع فى الواقع إلى تأثير عاملى المسافة والموقع الجغرافى . وقد اتضح أيضاً أن أكثر مديريات القطر كثافة فى السكان هى التى تلفظ بقاطنيها دواماً إلى مدينة القاهرة وينطبق هذا على المديريات القريبة من القاهرة والواقعة حول قمة الدلتا

(المنوفية والقليوبية والجيزة) وأيضاً على أكثر مديريات الوجه القبلى كثافة فى السكان (أسيوط وسوهاج وقنا) أما مديرية أسوان فلها وضعها الشاذ وظروفها الجغرافية الفريدة التى جعلت منها بيئة طاردة أسهمت وحدها بحوالى ٣ ٪ من جملة المهاجرين إلى المدينة فى سنة ١٩٤٧

أما المهاجرون من القاهرة إلى بقية أنحاء البلاد فمعظمهم من الموظفين الحكوميين أو التجار ويقطن ٥٩ ٪ منهم فى الوجه البحرى ، ٤١ ٪ فى الوجه القبلى وتتوقف أعدادهم فى مهاجرهم الجديدة على مجموعة من العوامل منها : البعد عن مدينة القاهرة ، ظروف المعيشة خارج العاصمة ، وموقف سكان الأقاليم الأصليين تجاههم . وقد تبين لنا أيضاً أن مديرية الجيزة تستأثر وحدها بحوالى ٢٤,٧ ٪ من جملة القاهريين المهاجرين منها ويرجع هذا إلى قربها من العاصمة مما جعلها تمثل فى الواقع امتداداً للقاهرة ، وأيضاً إلى وجود جامعة القاهرة .

أما الموضوع الثالث فيعالج تحركات السكان داخل المدينة ، وقد تسنى لنا هذا بحساب نصيب الهجرة فى تزايد السكان فى كل حى من أحيائها (وذلك بطرح الزيادة الطبيعية من الزيادة المطلقة) وقد أوضحت هذه الدراسة كيف أن الأحياء المركزية الداخلية تفقد سكانها بينما تتزايد معدلات الهجرة تزايداً كبيراً فى أحياء حلقة المدينة الخارجية . ولنعطى مثلا لهذا بحالة مصر الجديدة فقد بلغت معدلات الزيادة بالهجرة فيها ١٠,٥ ٪ فى السنة ، ٥,٢ ٪ ، ٦,٩ ٪ فى سنة ١٩٢٧ ، ١٩٣٧ ، ١٩٤٧ على التوالى ، مما يدل دلالة واضحة على عظم الدور الذى لعبته الهجرة فى تزايد السكان فيها .

المهندس على شافعى : مشاكل رى الصحارى :

إن الزيادة المطردة فى عدد السكان قد وجهت نظر البلاد التى ليست لها مستعمرات يهاجر إليها الفائض من سكانها — إلى الصحراء ومع كثرة ما كتبه الكتاب فى وصف جمالها وواحاتها وسرابها وغرودها فقد ابتعدت كتب الرى

التعدين فى قلب الصحراء ، وبخاصة استثمار البترول . وعناية الحكومات بنشر التعليم بين أبناء البدو . وهكذا نشهد اليوم تطوراً كبيراً فى الحياة الاجتماعية . كان من نتيجته التعاون والاتصال الشديد بين البدو والحضر . وتأثر البدو بالتيارات الاقتصادية والحياة الاجتماعية الجديدة ، التى تدفعهم شيئاً فشيئاً إلى نوع من الاستقرار يزداد وضوحاً على مدى السنين .

الدكتور كارل و. بوتزر : البيئة الطبيعية والبشرية فى مصر خلال عصر ما قبل الأسرات وأوائل عصر الأسرات :

يدرس المؤلف فى مقاله البيئة الطبيعية والبشرية فى مصر خلال هذه الفترة ويوجه عناية خاصة إلى السهل الفيضى لنهر النيل وصفاته الطبيعية وأثرها فى الموقع الجغرافى للقرى فى عصر ما قبل الأسرات ، كما يستقصى التغيرات المناخية وأثرها البيولوجى فى العصر الحجرى الحديث وفى عصر ما قبل الأسرات .

وفى رأى المؤلف أن الفترة بين ٥٠٠ ، ٢٣٥٠ سنة قبل الميلاد كانت أغزر مطراً من الوقت الحاضر وذلك دون أن تعتبر فترة مطيرة . وتتفق هذه الفترة وانتشار الحضارات الزراعية فى كل بلاد الشرق الأوسط .

ويورد المؤلف أخيراً ملاحظاته عن حضارات ما قبل التاريخ وتطورها وعلاقة ذلك التطور بتغيرات البيئة الطبيعية وبالعناصر البشرية المسئولة عن هذه الحضارات .

الدكتور جمال حمدان : بعض مظاهر جغرافية المدن فى العاصمة المثلثة :

يعرض هذا البحث لخمسة عناصر من جغرافية « المدن الثلاث » .

فيحلل موقع المدينة فى الإطارين العمرانى (أو الأكيومينى) والسياسى .

ثم ينتقل إلى حجم المدن الثلاث وتطورات نموها السكانى الحديث ، وينتهى إلى أن الخرطوم ليست أكبر مدن السودان ، بل أمدرمان ، وأن المجمّع المدنى المثلث يشمل نحو ربع مليون حالياً تمثل أكبر تركيز مدنى فى داخل النصف الشمالى من أفريقيا .

بعد هذا يدرس الأسس الوظيفية للمدن الثلاث . فنجد أمدرمان المدينة الوطنية ، والخرطوم المدينة « الأوربية » ، نجد الأولى بوجه عام جداً « المسكن » والثانية « المكتب » وخرطوم بحرى « المصنع » ، على الترتيب ، الجسم والرأس والأطراف . . . . وهذا التركيب يعنى قدراً وافياً من التكامل الوظيفى ، ولكن « الانسياح الأفقى » الشنيع فى تركيب البناء يهدد بتفكك وتراخ فى هذا التكامل .

يلى هذا دراسة ديموغرافية المدن : تحليل لتركيب السكان : الوطنيين والجاليات الأجنبية ، وتوضيح تركزاتهم وتجمعاتهم الرئيسية .

أما الجزء التالى فيحلل موضع المدينة المحلى ويتتبع نمو المنطقة المبنية ثم نمط خطة المدينة فى ضوء توجيهات الموضع والعوامل التاريخية .

ثم تأتى دراسة التركيب الوظيفى لداخل المدن . فيحدد توقيع الوظائف الرئيسية وأقاليم الوظائف الكبرى ، ونخلص إلى أن التركيب الوظيفى « ناضج » فى الخرطوم وحدها حيث يتبلور النظام الثلاثى : قلب وحلقة وسطى وحلقة خارجية . أما فى أمدرمان وبحرى فليس ثمة إلا نظام ثنائى / قلب وأطراف .

وينتهى البحث بدراسة تطبيقية تركيبية على أمدرمان ، وبخاصة « سوق » أمدرمان الشهير — أكبر « بازار » أفريقى فى القارة — معتمداً على دراسة حقلية مفصلة .

الدكتور محمد صفى الدين أبو العز : بعض نواحى الهجرة فى مدينة القاهرة :

موضوع الهجرة ، موضوع شائك تحول دون دراسته فى أغلب الأحيان صعوبات إحصائية عديدة على الرغم من أنه يعد بحق أكثر موضوعات الدراسات الديموجرافية صلة بعلم الجغرافيا . ويهدف هذا البحث إلى إبراز ظاهرة تبادل السكان بين القاهرة وبقية مديريات الإقليم المصرى ، وذلك بمعالجة هذا الموضوع من ثلاث نواح :

١ — نمو السكان فى مدينة القاهرة .

ملخص المقالات
المنشورة باللغات الأجنبية

Résumé des articles publiés en langues étrangères

الدكتور محمد عوض محمد : استقرار البدو فى الشرق الأوسط :

هذا المقال مقصور على الشرق الأوسط العربى ، ويعالج الأقاليم الثلاثة وادى النيل (مصر والسودان) والهلال الخصيب (العراق وسورية) والجزيرة العربية . وهى أقاليم اشتهرت دائماً بانقسام سكانها إلى بدو وحضر . وأشد القبائل بداوة فيها رعاة الإبل ، الذين يقطعون مسافات طويلة بحثاً عن الكلأ لدوابهم . ولذلك كانوا أكثر البدو اضطراباً وأبعدهم عن الاستقرار . أما رعاة الضأن ، فلا بد أن تكون مراعيهم قريبة . ولذلك يعدون نصف بدو ، وإقامتهم أكثر من ظعنهم . والبدو يحتلون جهات عديدة ، بعضها صالح للزراعة والاستقرار ، وبعضها يمكن بوسائل الرى المستحدثة أن يصبح صالحاً للحياة المستقرة . ولكن البدو لا يجنحون إلى الاستقرار إلا تحت ضغط الظروف . والحكومات المنظمة لا ترتاح كثيراً لأن تقوى شوكة البدو ، لأنهم كثيراً ما كانوا مصدر إضطراب فى حياة الأمم . وتحاول جهدها أن تحملهم على الاستقرار والتحضر . وهناك وسيلتان لتحقيق هذا الهدف : إما إتباع أساليب القهر والعنف وإلزام كل قبيلة أو جماعة بدوية بأن تلزم مكاناً لا تبرحه . وإما الالتجاء إلى الوسائل السلمية التى تعتمد على التطور الاقتصادى والاجتماعى . وبديهى أن الطريقة الثانية هى خير وأبقى وهى التى نرى أثرها فى الشرق العربى اليوم ، حيث نرى الاستقرار يتقدم فى أوطان البدو بسبب مشروعات الحياة الحديثة مثل السكك الحديدية ، وقيام مراكز للحكم ، وإنشاء المصايف ، واستنباط المياه بطرق جديدة ، ونشاط

المرحوم الأستاذ أحمد محمد العدوى

فى اليوم الثانى عشر من شهر يناير سنة ١٩٥٩ توفى إلى رحمة الله الأستاذ أحمد محمد العدوى رئيس قسم الجغرافيا السابق بكلية الآداب بجامعة الأسكندرية بعد حياة طويلة قضاها فى خدمة علم الجغرافيا .

تلقى الأستاذ العدوى تعليمه العالى فى مدرسة المعلمين العليا ، قسم الآداب ، وتخرج فيها سنة ١٩١٧ . وفى صيف ذلك العام سافر فى بعثة علمية للتخصص فى علم الجغرافيا والتحق بجامعة لفربول بانجلترا تحت إشراف العلامة الجغرافى المرحوم الأستاذ برسى مود روكسبى . وعهد إلى المرحوم الأستاذ العدوى ، بعد عودته من البعثة سنة ١٩٢٠ بتدريس مادة الجغرافيا فى المدارس الثانوية . وفى سنة ١٩٢٩ عين مدرساً فى كلية الآداب بجامعة القاهرة ، ورقى إلى وظيفة أستاذ مساعد ، واختير بعد عامين لإدارة فرع الكلية فى الأسكندرية . ثم عين بعد ذلك فى تلك الجامعة وشغل كرسى الجغرافيا بكلية الآداب ، وأصبح رئيساً للقسم واستمر فى هذا المنصب حتى سنة ١٩٥٤ حين اعتزل الخدمة لبلوغه السن القانونية .

وقد كان رحمه الله وفياً لأصدقائه وزملائه ، مخلصاً لعمله ، محباً لطلابه وموجهاً إياهم أحسن توجيه .

مصطفى عامر

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